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Tomus XXXVIII.

SUPPLEMENTUM

SZEGED, HUNGARIA
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NOTE TO CONTRIBUTORS

General

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The authors are responsible for the accuracy of their data, references and quotations from other sources.

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Manuscript should be typewritten with double spacing, 25 lines on a page and space for 50 letter in a line. Each new paragraph should begin with an indented line. Underline only words that should be typed in italics.

Manuscript should be generally be organized in the following order:

Title
Name(s) of author(s) and their affiliations, in foot-note the address of the author to whom the correspondence should be sent
Abstract
Introduction
Methods, techniques, material studied, description of the area investigated, etc.
Results
Discussion or conclusions
Acknowledgement
Explanation of plates (if any)
Tables
Captions of figures (drawings, photomicrographs, etc.)

Abstract

The abstract cannot be longer than 500 words.

Tables

The tables should be typewritten on separate sheets and numbered according to their sequence in the text, which refers to all tables.

The title of the table as well as the column headings must be brief, but sufficiently explanatory.

The tables generally should not exceed the type-area of the journal, i.e. 12,5x18,5 cm. Foldouts can only exceptionally be accepted.

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ACTA UNIVERSITATIS SZEGEDIENSIS

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Kiadja

a József Attila Tudományegyetem Ásványtani, Geokémiai és Kőzettani Tanszéke
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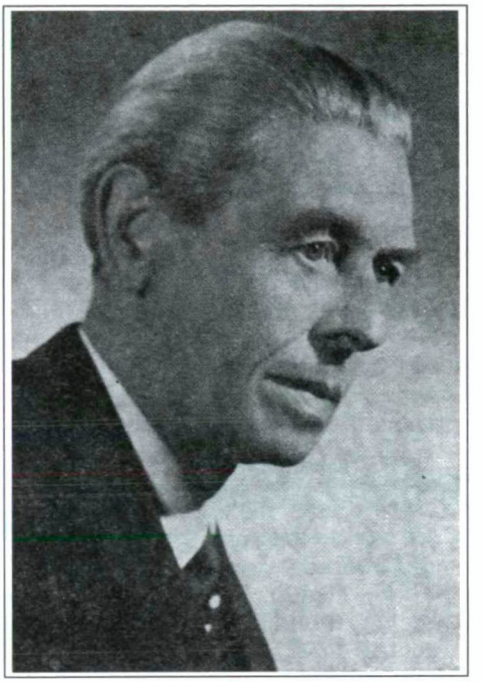

Sándor Koch
1896 – 1983

A centennial anniversary of birth of Prof. Sándor Koch was held in Szeged, 16–17. October, 1996. This festal event was arranged by Institute of Mineralogy, Geochemistry and Petrology of Szeged University and Hungarian Geological Society and „Sándor Koch TIT Organization" as well as „Sándor Koch Foundation".

On the first day numerous commemorations were delivered in the aula of Szeged University followed by a ceremonial unveiling of a memorial tablet at the entrance of Institute of Mineralogy, Geochemistry and Petrology. On the next day a centennial scientific session was held with fourteen lectures which introduced the newest home results of the branches of geological sciences cultivated also by Sándor Koch. This supplementum contains the texts of best selected lectures.

Prof. Sándor Koch was the starter of our periodical „Acta Mineralogica-Petrographica" 53 years ago. This extraordinary publication gives him a centennial remembrance from his old students and present-day followers.

Prof. Tibor Szederkényi

Acta Mineralogica-Petrographica, Szeged, XXXVIII, Supplementum, 7–63, 1997

SECONDARY SULPHATE MINERALS FROM HUNGARY

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ABSTRACT

An overview is given in this paper by genetic types about the secondary sulphate minerals that occur in the territory of Hungary. At present we know about 60 secondary sulphate minerals from Hungary (Table 1). Numerous rarities occur among them, including bonattite, fornacite, koktaite and millosevichite.

The secondary sulphate minerals of the sulphide ore deposits and ore indications are quite variegated, indicating the variety of precursor sulphide minerals. Especially variegated sulphate parageneses occur in the ore deposits of Nagybörzsöny, Recsk and Rudabánya. In magmatic and sedimentary rocks, jarosite and gypsum commonly form the weathering of disseminated pyrite and/or marcasite grains. Bauxite deposits are particularly enriched in iron-sulphates. Secondary sulphates can be found in large amounts in all coal beds and especially on the burning dumps. The important occurrences are Tokod, Egercsehi and Miskolc-Lyukóbánya. A species-rich sulphate paragenesis is known from Lesenceistvánd, where it formed by the weathering of the marcasite that impregnates the sandstone.

1. INTRODUCTION

The secondary sulphate minerals appear in superficial and near-superficial parts of different geological formations. They usually occur in sulphide-bearing rocks, forming mainly by the weathering of sulphide minerals. The most important environments of formation of the secondary sulphate minerals in Hungary are:

1. zones of weathering of sulphide ore deposits,
2. zones of weathering of rocks that contain disseminated sulphides,
3. superficial and near-superficial layers of salting areas,
4. openings of mine workings,
5. material of the refuse dumps,
6. museum (collection) specimens.

The environments of the formation of secondary sulphates, listed under 1 to 3 are independent of human activity, but in the case under 4 to 6 the appearance of sulphate-bearing paragenesises are caused by anthropogeny influence. We did not include to the

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[2] H-1143 Budapest, Stefánia u. 14.
[3] H-1083 Budapest, Ludovika tér 2.
[4] H-3545 Miskolc-Egyetemváros

group of secondary sulphates samples that formed by hydrothermal (epithermal) processes (such as the most of barite occurrences and alunite and jarosite of hydroquartzites). Evaporites and sulphate-bearing mineral assemblages of caves are not listed either, because they consist first of all of primary segregations.

The secondary sulphates quite frequently have been mentioned in the Hungarian mineralogical literature. Most of such papers discuss minerals of abandoned mine workings, dumps of coal beds, bauxite beds and clays (KOCH, 1985).

Based on the large amount of sulphate mineral samples found by the staff of the Herman Ottó Museum (Miskolc) with the help of numerous collectors, tens of thousands of microscopic investigations and thousands of instrumental tests were done in the period between 1986 and 1996. The most important results of this work are summarized in this paper.

The instrumental tests usually have been done within 1–2 mounts after collecting: this is quite important, because among the sulphates, new mineral phases could form by water loss in the period of storage. Moreover, by our opinion, partial water loss could be also caused by X-ray radiation during the tests, resulting in difficulties in the interpretation. This could occur if a test was done on a specimen that was collected long ago, on a museum specimens, or on a sulphate mineral which formed on a museum specimen. With regard to the wealth of information, in this paper only short descriptions are given, except for those species that are described here. Hopefully, it will be possible to treat some parts in more detail in the future. Former results are completed with our new data and classified in genetic order in Table 1.

2. METHODS OF EXAMINATION

In the first stage, the separation of the different mineral phases was done using an optical microscope. Then energy-dispersive X-ray (EDX), scanning electron microscopy (SEM) and X-ray powder diffraction (XRD) analyses were performed. If necessary, other tests (thermal and IR analyses, wet chemical analyses) were applied. In this paper only those minerals are listed which were exactly identified by instrumental tests (as a minimum we applied EDX, SEM, XRD). The microprobe and SEM analyses were done at the Department of Metallography of the University of Miskolc. The thermal and IR-tests were made in the Hungarian Geological Institute, the X-ray powder diffraction analyses at the Department of Mineralogy of the Eötvös L. University, in the Hungarian Geological Institute, in the X-ray Diffraction Laboratory of the MOL Corp., and in the X-ray Diffraction Laboratory of the ALUTERV-FKI. Tests that were done in other institutions are always mentioned, together with the conditions of the particular analyses.

Test conditions:

University of Miskolc, Department of Metallography: SEM-EDX: AMRAY 1830i, EDAX 9900, 20 kV accelerating voltage, 10^{-10} A probe current, SiLi detector, W-cathode.

Eötvös L. University (ELTE), Department of Mineralogy: XRD: SIEMENS 500D, CuK_{α}-ray, graphite monochromator, 41 kV accelerating voltage, 20 mA tube current, the rotation rate of the goniometer was 1 or 2 degree/minute.

MOL Corp. Laboratory for Oil and Gas Industry, X-ray Diffraction Laboratory: XRD: PHILIPS PW 1820, CuK_{α}-ray, graphite monochromator, 40 kV accelerating voltage, 30 mA tube current, rotation step by step by 0.05 degree with count time of 1 sec.

Hungarian Geological Institute (MÁFI) X-ray Diffraction Laboratory: XRD: PHILIPS PW 1710, CuK_{α}-ray, graphite monochromator, 40 kV accelerating voltage, 30 mA tube current, rotation step by step by 0.04 degree with count time 1 sec.

MÁFI Thermoanalytical Laboratory: Derivatograph-C, heating rate 10°C/minute.

It is not possible to publish in this paper the documentations of each tests, but for the important specimens, the adequate test numbers and inventory numbers are mentioned. For the jarosite and copiapite groups additional analyses were necessary for further separation. XRD and EDX methods were used essentially for the investigation of the minerals of the quite frequently occurring jarosite group; using these two methods, the minerals of the jarosite group could be satisfactorily distinguished. When potassium and iron were detected together with sulphur in a jarosite-bearing phase, then we listed the mineral as jarosite. Numerous unidentified species of this group could still exist in Hungary because of the variable cation substitutions; in the future, it will be necessary to obtain more wet chemical analyses on these minerals.

3. SULPHIDE MINERALS AND THEIR OCCURRENCES

Because of the large number of occurrences, a genetic classification was applied for the description of the parageneses of secondary sulphate minerals. Within a genetic type, the minerals are listed by mountain ranges, or by occurrences, from west to east.

3.1. SULPHIDE ORE DEPOSITS AND ORE INDICATIONS

The ore deposits are ideal environments for the formation of secondary sulphate minerals. Three main environments of the oxidation of sulphide minerals are known: the oxidation belt near the surface, the walls of mine workings (especially the abandoned ones) and the dumps. Variegated sulphate mineral assemblages could be formed on different deposits, because of the variety of sulphide minerals (see Table 1).

Szabadbattyán

Sulphate minerals from this deposit are not mentioned in the monograph by KOCH (1985). Anglesite was described by KISS (1951) but was not found by us. Among the secondary sulphates, *gypsum* and *jarosite* occur rarely on the dump of the lead ore occurrence. Gypsum forms 2–3 mm long, acicular crystals, while jarosite occurs in light-yellow, dust-like tarnish. *Fornacite* was found once; this is the first finding of this mineral in Hungary, so we describe it in more detail.

Fornacite $CuPb_2(CrO_4AsO_4)(OH)$

This rare copper-lead-chromate-arsenate, which is included in the class of sulphates, was found on a museum specimen collected by PÁL KRIVÁN in the 1940's (HOM 21629). Bindheimite and malachite also appear in this specimen that consists mostly of cerussite. Fornacite occurs in the cracks of cerussite. It is darker than bindheimite, has a wine-yellow colour, glassy lustre, in places forming thin-tabular crystals of 10–40 μm, or 100–300 μm size (Fig. 1). The crystals rarely form crusts on the walls of the cracks. 21 reflections of fornacite were detected on the XRD patterns, which are in good agreement with the data in the JCPDS card 15-200 (Table 2). Cu, Pb, As and Cr were detected by the EDX analysis,

so the occurrence of fornacite can be considered as certain. The appearance of fornacite fits well into the suite of secondary sulphate minerals of the Szabadbattyán ore deposit, where Cu-, Pb- and As-bearing sulphides (e.g., galena, chalcopyrite, tetrahedrite) were found.

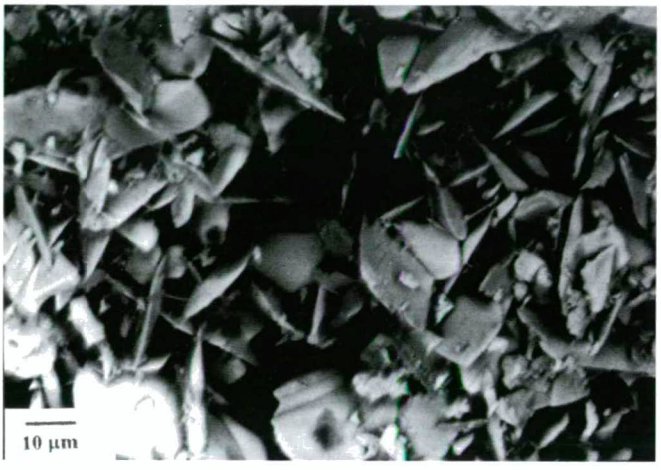

Fig. 1. Fornacite, tabular crystals, Szabadbattyán. Scanning electron micrograph.

Pátka

Jarosite occurs commonly and *gypsum* less commonly in the cracks and cavities of the siliceous-fluorite-bearing veins of the outcropped ore occurrences in the Kőrakás Hill and near the Szűzvár mill. Jarosite occurs in yellow, dust-like spots, and gypsum usually forms columnar crystals with sizes less than 1 mm. Anglesite – which was described by numerous authors – was not detected yet by our instrumental tests.

Sukoró

Jarosite occurs commonly in the formations of the ore indication on the Ördög Hill. The accompanying minerals are goethite, cerussite, sulphur and malachite.

Nadap

Yellow, dust-like dissemination of *jarosite* appears quite frequently, together with goethite and alunite in the widespread quartzite of the Meleg Hill. It occurs also commonly in the cracks and cavities of the material of the Nadap adit, where it was formed by the weathering of pyrite. By the XRD patterns, *plumbojarosite* occurs also in the cavities of the quartzite of the enargite-bearing indication, near Likas-kő. Plumbojarosite forms here yellow, dust-like tarnishes. The accompanying minerals are goethite, or more rarely bayldonite, forming yellowish-green tarnish, and a copper-arsenate mineral that occurs in light-blue crusts and has yet to be identified. These above listed arsenates appear directly in the surroundings of enargite grains, usually enclosing them, or in places enargite is fully replaced by these arsenates. 14 reflections of bayldonite were identified on XRD pattern G241, together with 2 reflections of plumbojarosite: the

100 at d=3.079 (3.066), and the 95 at d=5.96 (5.93). The values in the brackets are the corresponding values from JCPDS card 18-698 of plumbojarosite. Pb, Fe and S were detected by the EDX analysis of the jarosite-bearing phase, confirming the result of the X-ray diffraction.

Nagybörzsöny

A sulphate-rich paragenesis is known form the mine workings, which were opened by the surveying of the ore occurrence in the second part of this century. A review is provided by NAGY (1984). *Kröhnkite* was described by ERDÉLYI *et al.* (1957) with question mark and after that it was not possible to find another specimen of this mineral – we consider as uncertain information.

We found a significant amount of sulphates on the dumps near Rózsa Hill that were not yet described from this area. Recent sulphate bloomings have been formed in large amounts on the surface of the pyrite-marcasite-bearing rocks on the dumps of the Altáró and Lower Rózsa adit along with arsenates (SZAKÁLL *et al.*, 1994). The following sulphate minerals were identified by XRD, thermal, SEM and EDX tests: copiapite, gypsum, jarosite, melanterite, rozenite, römerite, siderotil, szomolnokite and voltaite. From these, jarosite and gypsum are widespread. Jarosite occurs commonly on the dump of the Upper Rózsa adit, in the material of the small outcrops on the peak of Rózsa Hill (SZAKÁLL *et al.*, 1995), and also on the dumps of the Lower and Upper Fagyosasszony adits. *Copiapite* appears in 2–3 mm-sized, yellow aggregates; *melanterite* forms greenish incrustations; *rozenite* occurs in 1–2 mm-sized, white, curved, fibrous aggregations; *szomolnokite*, together with rozenite can be found in dust-like aggregates, and *voltaite* appears in crusts of 0.1–0.2 mm-sized, poorly developed, black crystals (XRD C271, C272, L173). *Anglesite* appears rarely in the vein quartz of the Altáró, forming sub-millimetric, white, sawtooth-like crystal groups and white segregations on the quartz, together with arsenopyrite and galena (XRD C285). Among the sulphates that were identified from this deposit, *römerite* and *siderotil* were first found here in Hungary, so we introduce them in more detail.

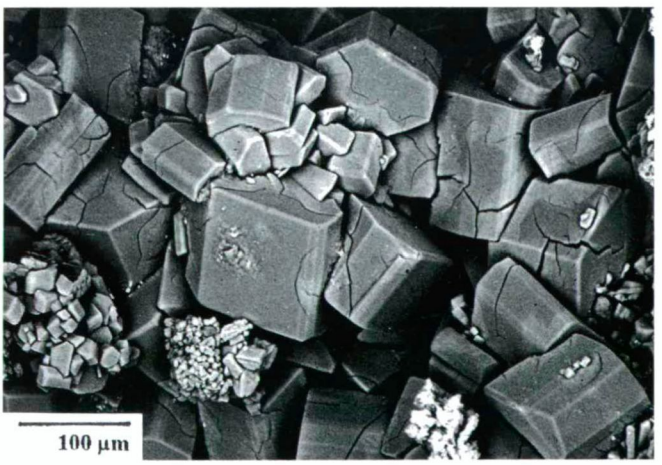

Fig. 2. Römerite crystals, Nagybörzsöny, drain adit. Scanning electron micrograph.

Römerite $Fe_3(SO_4)_4 . 14H_2O$

It was found in a sulphate-rich paragenesis, on the dump of Altáró. It forms 1–2 mm long, loose crusts and aggregates of sub-millimetric, light-pink crystals on the weathered surface of pyrite and marcasite (HOM 20820), and occurs in self-contained masses. By the SEM analyses, the stumpy crystals have 50–200 μm size and they are usually cracked (Fig. 2).

Wet chemical analysis of römerite from Nagybörzsöny give the following results:

	by specimen	by HÖLZEL (1982)	theoretically
Fe_2O_3*	27.3	29.3	29.8
H_2O	[29.5]	30.98	31.3
SO_3	40.3	38.4	39.8
Σ	97.1	98.68	100

*summarized FeO and Fe_2O_3.
[ ] – calculated from thermal analysis.
Analyzed by Mrs. I. SOHA (MÁFI).

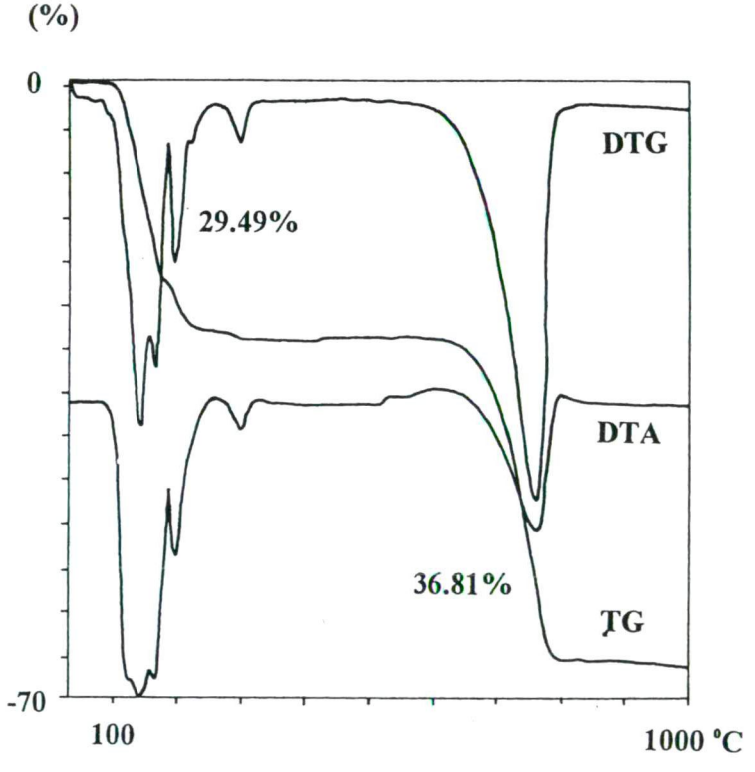

Fig. 3. Thermoanalytical curves of römerite from Nagybörzsöny.

The reactions that appear on the thermoanalytic curve (Fig. 3) are:

on the specimen		by TSVETKOV and VALYASCSHIKHINA
139–142 °C endothermic	16.79%	80–105 °C endothermic
165.3 °C endothermic	6.05%	105–135 °C endothermic
193–195 °C endothermic	5.4%	175–200 °C endothermic
296–298 °C endothermic	1.25%	220 °C endothermic
526.5–530.3 °C exothermic	?	410–620 °C exothermic (570 °C)
760–762.3 °C endothermic	36.81%	620–770 °C

The ignition losses by the TG curve are 67.16%.
The water-content and the ignition losses on the curve, published by CVETKOV and VALYASCSHIKHINA (1955) are 28.82% and 67.59%, respectively. This means that the curves of the test correlate well with the published data.

17 reflections of römerite were identified on the X-ray diffractogram (C273). The reflections with largest relative intensities are: the 100 – 4.78 (4.79), the 90 – 4.04 (4.03), the 50 – 5.08 (5.05) Å d values.

Fig. 4. Siderotil crystals, Nagybörzsöny, drain adit. Scanning electron micrograph.

Siderotil $(Fe,Cu)SO_4 . 5H_2O$

Together with other sulphates, it occurs on the weathered surface of the pyrite-marcasite-bearing rocks of the Altáró. The 2–5 mm sized siderotil crusts – formed by intergrowths of sub-millimetric, light-brown crystals – are accompanied by melanterite (HOM 23622). According to SEM images, these crusts are formed by 20–50 µm-sized, stumpy crystals, occasionally grouping into spherulitic aggregates (Fig. 4). The identification of this mineral was based on the XRD patterns No. C270 (Table 3), where 22 reflections appeared, in good agreement with the data of JCPDS card 22-357. The reflections of melanterite, gypsum, pyrite and quartz were detected together with siderotil on other XRD patterns (G270). An iron sulphate was detected by the thermal analysis,

obtained from a small amount (6.4 mg) of the sample, but the information is not enough for a detailed identification. The EDX test confirmed the presence of Fe, S and Cu.

Salgótarján

Gypsum and *jarosite* appear in minute amounts in the polymetallic ore indication of the andesite quarry of Karancs Hill, accompanying the altered sulphides.

Parádsasvár, Béke adit

Secondary sulphates are not mentioned in the literature (KOCH, 1985), but in the last years they have been intensively formed on the dump of the Béke adit. By the instrumental tests, the following minerals were identified: azurite, cerussite, devilline, gypsum, goethite, hematite, hemimorphite, hydrozincite, jarosite, cuprite, malachite and copper. Among the sulphates, *jarosite* forms dust-like tarnish, *gypsum* appears in mm-sized, acicular crystals, and *devilline* occurs in 0.2–0.6 mm sized, thin-tabular or lath-shaped, sky-blue crystals or in radial aggregates. This is the second appearance of devilline in the Mátra Mountains. It seems that the chalcopyrite- and calcite-rich material of the dumps of the Middle Mátra is a suitable environment for the formation of devilline. It commonly formed on the surface of the chalcopyrite crystals, accompanied by kaolinite. The five largest reflections appeared on the diffraction patterns, which agree well with the data on the JCPDS card 35-0561. The presence of Ca, Cu and S was identified by EDX, in agreement with the composition of devilline.

Gyöngyössolymos, prospect pit on Névtelen-bérc

The weathered dump of the prospect pit has been enriched by secondary sulphate minerals in the last years. According to KOCH (1985) and by our research, the following secondary minerals were detected: devilline, gibbsite, gypsum, goethite, greenockite, jarosite, kaolinite and malachite. *Gypsum* and *jarosite* appear commonly, whereas *devilline* occurs more rarely.

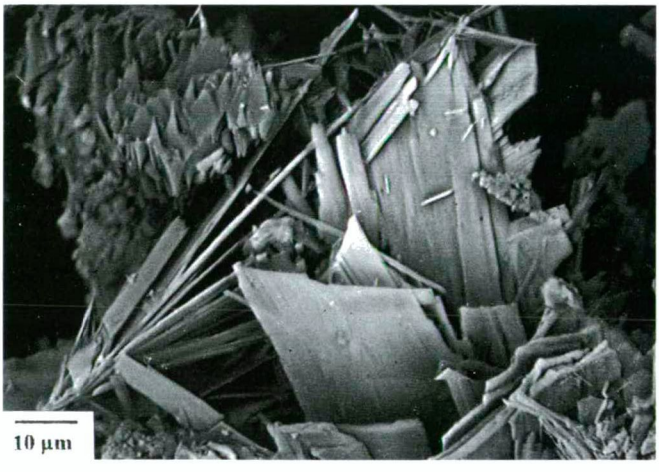

Fig. 5. Devilline, lath-like crystals, Gyöngyössolymos, Névtelen-bérc adit. Scanning electron micrograph.

Devilline $CaCu_4(SO_4)_2(OH)_6 \cdot 3\,H_2O$

The sky-blue, lamellar aggregations of devilline occur directly on chalcopyrite or in the cavities of vein quartz, forming 1–3 mm-sized radially-fibrous aggregates (HOM 22239). SEM images show that the aggregates consist of 20–80 μm long, lamellar and lath-shaped crystals (Fig. 5). Devilline usually appears with malachite and clay minerals. Three reflections of devilline, quartz, calcite and an unidentifiable clay mineral appear on the XRD patterns that where obtained from a small amount of the sample. The three reflections – which are the strongest reflections of devilline – do not overlap with other peaks and correspond to the three largest reflections published on JCPDS card 35-0561 of devilline:

Devilline from Névtelen-bérc:	10.23	5.12	3.40 (Å)
Devilline by JCPDS 35-0561:	10.22	5.10	3.39 (Å).

The diffractogram alone would not have been enough for the detection of devilline, because the three largest reflections of serpierite appear very close to the above listed values; however, EDX detected only Ca, Cu and S from these crystals. Since no Zn was detected, the presence of serpierite could be excluded.

Gyöngyössolymos, pits of Nyírjes

Only *jarosite* and *gypsum* were found from the sulphates on the weathered dumps. Goethite, hematite, malachite, copper, cuprite and clay minerals appeared as accompanying secondary minerals.

Recsk, Lahóca Hill

The earlier information about the sulphate-rich paragenesis of the old pits of the Lahóca Hill were summarized by KOCH (1985).

Secondary sulphates have been formed frequently by weathering on the dumps of Lahóca Hill. Jarosite and gypsum appear commonly. Chalcanthite also occurs, especially on the dump of the Rm-48 inclined adit. *Jarosite* forms yellow, dust-like tarnishes and *gypsum* appears in transparent, acicular aggregates. *Chalcanthite* forms ink-blue spots with glassy lustre in the cavities of the enargite-pyrite-bearing ore. *Szomolnokite* could be found frequently on the surface of the marcasite-bearing specimens that weathered during storage. It was formed probably as a pseudomorph after melanterite crystals, forming ocher-brown, massive, 1–3 mm-sized crystals with rough surfaces. 22 reflections of szomolnokite were identified on the X-ray diffractogram (G340). The three largest reflections with their relative intensities are: 100 – 3.42 (3.43), 40 – 3.08 (3.11), 34 – 2.51 (2.52) Å d values. (The data of the JCPDS card 21-925 are between brackets). Together with szomolnokite, the reflections of marcasite and quartz appear with small intensities. Rozenite and copiapite were detected in the close environment of the szomolnokite.

Coquimbite was detected by the X-ray powder patterns from a sulphate-bearing sample from the Lahóca Hill, Katalin level in the collection of the ELTE (K 100638) (oral communication of T. G. WEISZBURG).

Recsk, deep level

Numerous recent sulphate minerals were found in the adits of the Recsk deep level ore deposit (KISS & JÁNOSI, 1993). Unfortunately, a part of these were published without detailed information, so the appearance of these sulphates – by our opinion – is not fully

certain. The minerals which were detected by manifold instrumental tests (XRD, EDX, SEM) are the following ones: blödite, brochantite, chalcanthite, epsomite, thenardite and gypsum. From these recent segregations we also identified siderotil, sideronatrite and bonattite.

Siderotil was found by XRD (V153), occurring in yellowish-green crusts and in botryoidal aggregates. Nearly all 22 reflections of siderotil that are listed on JCPDS card 22-357 appeared on the diffractogram. Reflections with largest intensities were: 100 – 4.89 (4.89), 80 – 3.72 (3.73), 60 – 5.61 (5.57) Å d values (the data of the JCPDS card are listed in the brackets). The reflections of palygorskite were also found with small intensities. Fe- and S-contents were detected form these segregations by EDX.

Sideronatrite $Na_2Fe(SO_4)_2 \cdot 3H_2O$

This is the first occurrence of sideronatrite in Hungary. Its appearance is not surprising, because it is the iron-bearing analogue of the quite common magnesium-bearing blödite. Sideronatrite forms yellowish-brown crusts and spherulitic incrustations among the segregations of the level on –700 m (HOM 18722). The sub-millimetric spherules of the incrustations consist of radiating aggregates of 40–80 μm long, acicular crystals (Fig. 6.). According to XRD patterns, the accompanying minerals are halite and blödite. 18 reflections of sideronatrite were detected on the X-ray powder diffractogram (V154) (Fig. 7.). The largest reflections appeared at: 100 – 10.3 (10.2), 80 – 3.06 (3.01), the two 60 – 3.41 (3.38) and 2.72 (2.68) Å d values (data of the JCPDS card 17-158 are listed in brackets). Na, Fe, S and a small amount of Mg were detected by EDX.

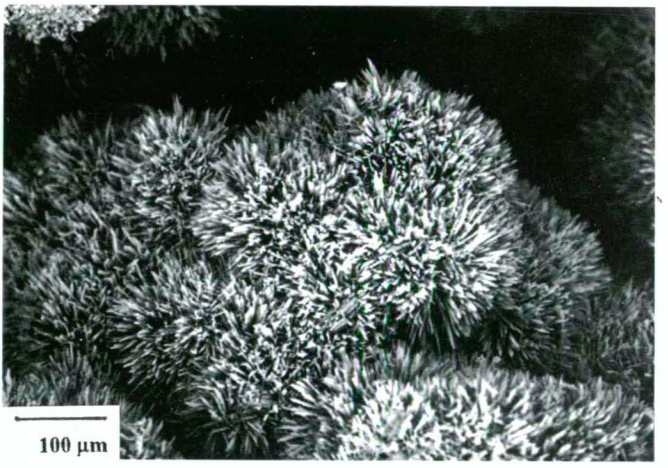

Fig. 6. Sideronatrite sprays, Recsk, –700 m level. Scanning electron micrograph.

Bonattite $CuSO_4 \cdot 3H_2O$

The quite rare *bonattite* is known from Hungary only from this deposit. It occurs in bluish-green incrustations, together with the dominant dypingite and with eriochalcite. We detected it by XRD, EDX and SEM tests. The 50–100 μm-sized spherules consist of radiating aggregations of lath-shaped crystals (Fig. 8.). 19 reflections of bonattite

appeared on the X-ray powder patterns (G350). The largest reflections, which appear without overlapping are at: 100 – 4.39 (4.41), 70 – 5.09 (5.10), 60 – 3.64 (3.64) Å d values (the data of the 22-249 JCPDS card is listed in the brackets). Cu and S were detected by EDX.

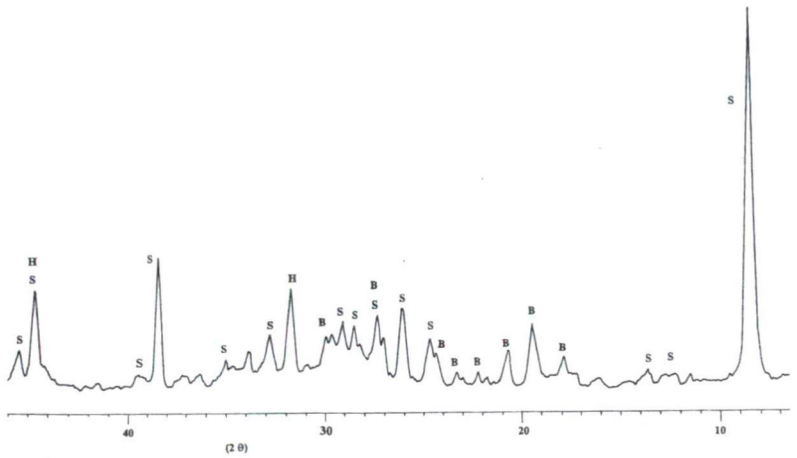

Fig. 7. X-ray powder diffractogram of sideronatrite, blödite and halite, Recsk, –700 m level. MOL Ltd., Budapest

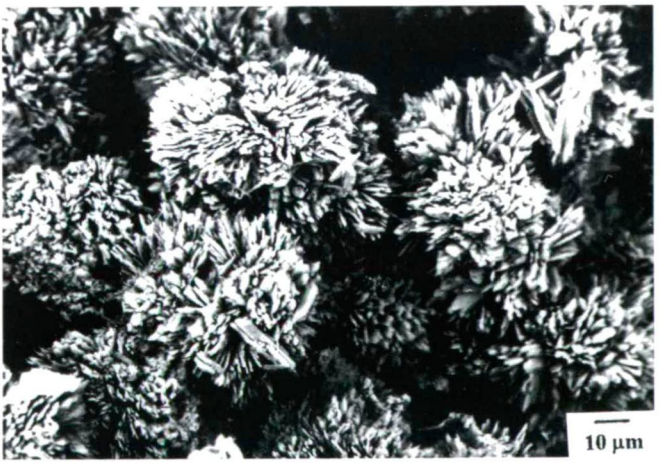

Fig. 8. Bonattite, globular aggregates. Recsk, –700 m level. Scanning electron micrograph.

Parád-Parádfürdő, Egyesség adit

Significant amount of ore-bearing specimens occur in the large depositing tanks that were used for alum production and are in front of the adit. Because of the abundance of water, sulphate-bearing blooms appear quite frequently in this area two arsenate segregations were found, too, but they are still not accurately identified). Coquimbite, gypsum, halotrichite and jarosite were detected from the sulphates by the instrumental tests (XRD V60, V87-88, C223). *Halotrichite* forms white, fibrous aggregates, *gypsum* occurs in colourless, acicular crystals and *jarosite* in yellow, dust-like tarnish.

Coquimbite $Fe_2(SO_4)_3 . 9H_2O$

Coquimbite in Hungary was first found here, as brownish-yellow, yellow crusts and aggregates, together with halotrichite. 25 reflections of coquimbite were detected on the X-ray powder patterns (Fig. 9.). The largest ones were at: 100 – 8.33 (8.26), 75 – 2.76 (2.75), 65 – 5.49 (5.45) Å d values (the data of the JCPDS card 6-0040 are listed in brackets). The reflections of the quartz, kaolinite and a not identified phase appear, too on the diffractogram. Fe and S were detected by EDX.

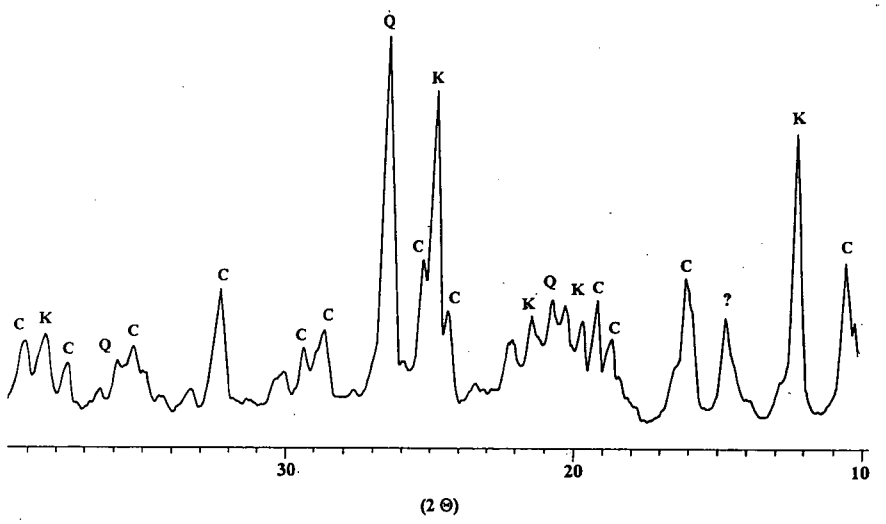

Fig. 9. X-ray powder diffractogram of coquimbite, kaolinite and quartz, Parád-Parádfürdő, Egyesség adit. Dept. of Mineralogy, ELTE, Budapest

Gyöngyösoroszi

The secondary sulphates of the Gyöngyösoroszi ore deposit were summarized by NAGY (1986). Based on XRD and EDX tests we complete this list with *thenardite* and *anglesite.*

Thenardite was found on the walls of mine workings, on the –100 m level of the Aranybánya adit, forming white, flour-like bloomings (HOM 19869). *Aglesite* was found in sub-millimetric, white spots or flour-like tarnish on the surface of galena crystals (XRD

C283). A characteristic secondary sulphate paragenesis has been formed by the weathering of sulphides in quartz veins, disseminated ore minerals, outcropping near the Upper Károly adit. It contains covellite, sulphur, malachite, gypsum, goethite, jarosite, hematite and anglesite. *Anglesite* – formed by the weathering of galena – occurs in crusts of sub-millimetric crystals on quartz.

Rudabánya

This large open pit is an ideal environment for the deposit of the secondary sulphates considering that the sulphide-bearing formations have been recovered on a large area. In addition to the information provided by KOCH (1985) and NAGY (1982), we detected the following sulphates that were unknown so far from this area: antlerite, botryogen, brochantite, copiapite, devilline, fibroferrite, jarosite, linarite, magnesiocopiapite, plumbojarosite, posnjakite, rozenite, serpierite, slavikite, starkeyite, siderotil and szomolnokite.

Brochantite (by XRD and EDX tests) appears in the cavities of the limonite ore of the Adolf mine, forming emerald-green, radiating spherules, intergrown with malachite, or forming self-contained, 50–200 μm-sized, thin-prismatic crystals in the cracks of the smithsonite, and also forming crusts. Parallel intergrown crystals occur quite commonly.

Jarosite is a widespread mineral in the outcrops, but usually occurs in small amounts only. It was found as a characteristic member of the sulphate paragenesis of the overlying lignitic seams, where the yellow, dust-like aggregations of this mineral appear together with melanterite, gypsum, rozenite and szomolnokite. This sulphate-bearing assemblage formed by the weathering of marcasite-pyrite concretions. In some outcrops of the Adolf mine, the clay, which is disseminated with pyrite, has a bright-yellow colour because of its fine dispersed jarosite content.

Siderotil

It was detected by XRD and EDX (G347) from the recent segregations of the Vilmos mine, where it occurs together with copiapite, forming brownish-yellow crusts.

Copiapite

It is a quite common sulphate, detected by us in the outcrops of all mines. Usually it forms 1–3 cm thick, pale-yellow, lemon-yellow, rarely orange crusts. On SEM images, the surfaces of these segregations consist of poorly developed and lamellar aggregates. By XRD, EDX and wet chemical tests, this mineral occurs here with variable compositions. Aluminocopiapite and gypsum were detected together with hexahydrite from the G232 specimen. The presence of these minerals was confirmed by thermal analyses. Aluminocopiapite is the main mineral of the G231 specimen with accompanying fibroferrite and gypsum. The G146 specimen consists of magnesiocopiapite, szomolnokite and rozenite in nearly equal proportions. Considering the positions of the thermal reactions and the proportions of the TG steps, the composition could also corresponds to magnesiocopiapite, but the steps of the water losses are different from the published reactions. By the X-ray patterns, the G145 specimen (Vilmos mine) consists of magnesiocopiapite (33 reflections), rozenite (20 reflections) and gypsum (8 reflections). The result of the XRD test was confirmed by thermoanalytic data, that showed ignition losses of 66.24%, measured up to 1001 °C.

The following thermal reactions appear on the curve of a sample that weighed 93.9 mg:

°C	weight changes (%)	reaction	
133–136	–11.88	loss of molecular water	
193	–13.55	loss of molecular water	
316–323	–0.87	loss of molecular water,	total water-content: 29.1%
356–362	–2.65	loss of molecular water	
431–483	+0.46	oxidation	
533–535	–0.15	dehydroxylation	
775.6	–29.32	decomposition of Fe-sulphate	
865–877	–2.04	decomposition of Al-sulphate,	total SO_3- content: >36.6%
>1000	–>5.23	decomposition of Mg-sulphate.	

The proportions of the reactions refer most likely to magnesiocopiapite with a small Al-content, but the steps of the reactions do not fully correspond to the published data. The presence of an iron sulphate mineral could be presumed by the amount of the weight loss near 360 °C.

By the wet chemical analyses (M. BRAUN, Kossuth L. University, Debrecen), the MgO-content of the copiapite minerals from Rudabánya varies between 3.58 and 5.79%, so this fact confirms also the presence of magnesiocopiapite among these sulphate-bearing segregations.

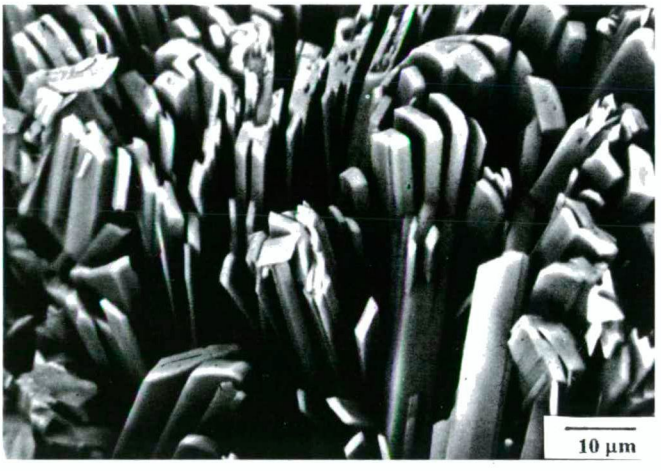

Fig. 10. Devilline, lath-like crystals, Rudabánya, Villanytető. Scanning electron micrograph.

Devilline

It was found in two outcrops from the open pit. In the outcrop below the „Villanytető" (Andrássy I mine), it was formed by weathering of copper-sulphides, occurring together with gypsum, jarosite, goethite, dolomite, claraite, barite and malachite in the fissures of the barite-bearing zone. Devilline segregations are usually associated with the 1–4 mm-sized tetrahedrite patches, forming crusts or appearing in their closest environment (HOM 24016). The sky-blue, lath-shaped, 0.2–0.5 mm long crystals are usually grouped into radiating or spherulitic aggregates, or they cover surfaces of a few cm^2 area (Fig. 10.). 21

reflections of devilline appeared on the XRD patterns (H2) (Fig. 11.). The largest ones occurred at: 100 – 10.20 (10.22), 95 – 5.10 (5.08), 80 – 3.19 (3.38) Å d values (the data of the JCPDS card are 22-231 listed in the brackets). 12 distinct reflections of the rare mineral claraite were detected on this diffractogram, from which only 3 are overlapped. Claraite was detected by EDX and SEM; the greenish-blue, 100–200 μm long crystals of this mineral are lath-shaped and usually form spherulitic aggregates. Ca, Cu and S were detected by most of the EDX tests of the devilline crystals; small amounts of Zn appeared in some analyses. Devilline was rarely found in the cracks of the earthy smithsonite in parts of the Adolf mine that are rich in secondary sulphates. Devilline forms 0.2–0.4 mm-sized, lamellar aggregates, accompanied by aurichalcite and cerussite.

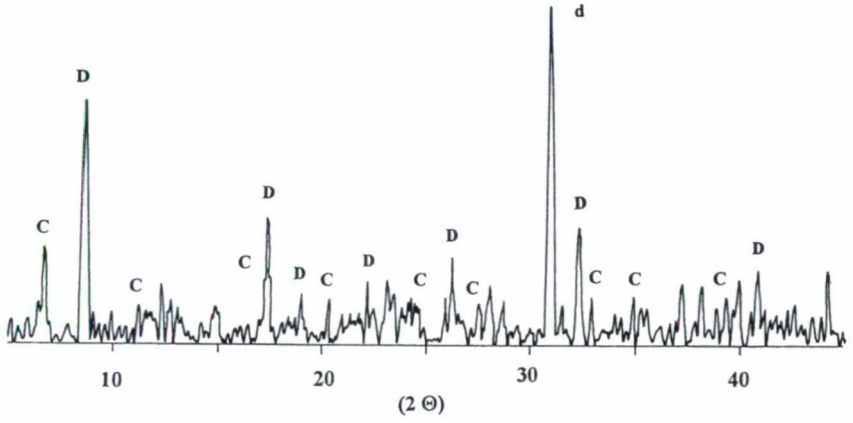

Fig. 11. X-ray powder diffractogram of devilline, claraite and dolomite, Rudabánya, Villanytető. Dept. of Mineralogy, Steiermärkisches Landesmuseum Joanneum, Graz.

Plumbojarosite

It occurs in the cavities of the siliceous limonite of the Adolf mine, forming 0.2–0.6 mm-sized, light-brown or yellowish tabular crystals with development of the basal and the rhombohedral faces or appearing in incrustations (HOM 22113). The presence of this mineral was confirmed by XRD (G82) and EDX (Pb-, Fe-, S-content) tests. The largest reflections occur on the X-ray patterns at: 100 – 3.068 (3.066), 95 – 5.93 (5.93), 35 – 3.11 (3.11) Å d values (the data of the JCPDS card 18-698 are listed in the brackets). The common accompanying minerals are beudantite, cerussite and malachite.

Rozenite and *szomolnokite* were found by us in the northern part of the Andrássy II. mine, in the lignite seams of the covering clay layers (G234). Pyrite and marcasite appeared frequently both in the lignite and in the clay, forming nodules of a few cm size. Rozenite and szomolnokite formed by the weathering of these nodules, close to the surface. Rozenite and szomolnokite were detected from the yellow, crust-like blooms of the Vilmos mine, too (G146).

Starkeyite, hexahydrite, epsomite

They are probably the most widespread minerals on the surface of the extended outcrops of the Vilmos, Andrássy I., and Andrássy II. mines. They form white or colourless, vitreous crusts, or white, flour-like disseminations. After desiccation, they turn into a white dust. They occur especially frequently in the Vilmos mine, on the walls of the adit below the so-called „Majomtelep", forming 2–5 cm thick crusts. Hexahydrite (62 reflections), starkeyite (43 reflections) and gypsum (19 reflections) were detected on the G114 X-ray patterns. Epsomite (27 reflections), hexahydrite (42 reflections) and gypsum (11 reflections) appeared on the G229 diffractogram with the dominance of epsomite. Similar phases were found in other specimens from this area (G230, G348), but in these the dominant mineral was hexahydrite. In the G232 specimen, the dominant hexahydrite is accompanied by gypsum and copiapite.

In the following part, antlerite, botryogen, fibroferrite, linarite, posnjakite, slavíkite and serpierite will be described in detail, because these were first in Hungary in Rudabánya.

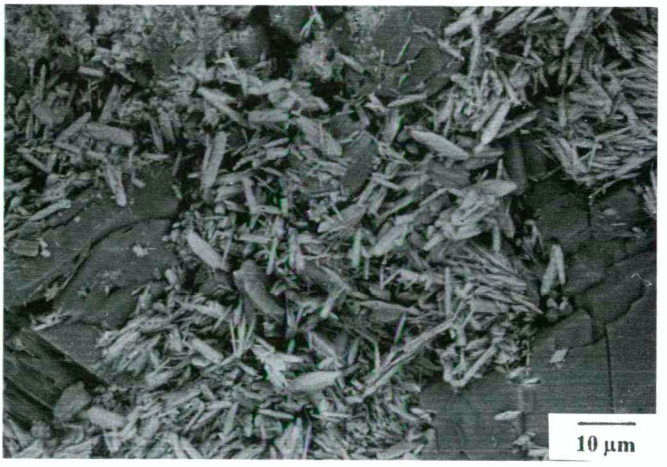

Fig. 12. Antlerite needles, Rudabánya. Scanning electron micrograph.

Antlerite $Cu_3SO_4(OH)_4$

It was found in numerous places of the oxidation zone of the Rudabánya iron ore deposit. By our investigations, it is the most frequent copper sulphate. It occurs together with malachite in the cracks of the brown iron ore, in the outcrops below the „Villanytető", forming light-green, dust-like dissemination. We have two series of the collected specimens (HOM 19621, HOM 20152) which contain antlerite, but their locality cannot be identified. In one of these, antlerite forms light-green, loose, dust-like, sometimes spherulitic aggregations on the walls of the cracks in the brown iron ore. In SEM images, these aggregations consist of acicular, 5–25 μm long crystals (Fig. 12). Malachite, barite and goethite appear in the closest environment of these aggregations. In the other occurrence in lignite the light-green, dust-like aggregates of this mineral are accompanied by fibrous segregations of chalcanthite. All these observations point to the secondary genesis of antlerite in the zone of oxidation. Usually it formed together with malachite, probably by the weathering of chalcopyrite. On the other hand, sometimes it has another

genesis, as we found a 2 cm thick vein-filling, which consist of small covellite lamellae covered by a thin crust of antlerite (G297).

The result of the wet chemical analysis (in weight%) is the following:

	from Rudabánya	by HÖLZEL (1992)
CuO	64.4	67.08
H_2O	[8.8]	10.22
SO_3	26.8	22.40
Σ	100	99.70

Analyst: Mrs. I. SOHA (MÁFI) (the H_2O was calculated by the completing to 100%).

13 reflections of the antlerite appear on the XRD patterns, which correlate well with the data of the JCPDS card 7-407 (Table 4).

Fibroferrite

It was found among the recent segregations in the Vilmos mine, from the lower part of the so-called „Vilmos-Nagyfal" (HOM 23584). It occurs in yellowish, fine-grained crusts, together with dominant aluminocopiapite. The detected reflections mostly relate to the JCPDS card of aluminocopiapite. Aluminocopiapite has 31 reflections, fibroferrite 19 reflections and gypsum 12 reflections on the XRD diffractogram (G231). By the peak-widths, the specimen contains aluminocopiapite in 80% and fibroferrite in 10%. The largest reflections of the fibroferrite appear at: 100 – 11.7 (12.1), 80 – 2.97 (2.98), the three 60-s – 6.83 (6.96), 3.45 (3.43) and 2.77 (2.78) Å d values (Fig. 13.). From these, only the reflection by 3.43 Å is overlapped (the data of the JCPDS card 16-935 are listed in the brackets).

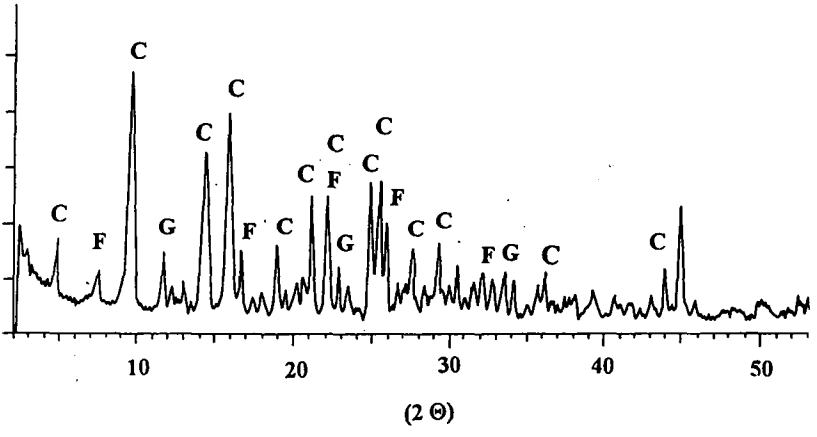

Fig. 13. X-ray powder diffractogram of fibroferrite, copiapite and gypsum, Rudabánya. MÁFI, Budapest

On the curve of the thermal analysis (Fig. 14.), the arrangement of the reactions and the proportions of the steps correspond to copiapite. The steps of the reactions are slightly different from the published data, indicating that this specimen first of all contains an OH-bearing, three valent iron sulphate mineral (fibroferrite by XRD).

Ignition losses measured up to 1000.3 °C were 62.19%.

The following thermal reactions appeared on the curve of a sample that weighed 102.4 mg:

°C	weight losses (%)	reaction	
133–136	12.35	loss of molecular water	
193–196	14.58	loss of molecular water	total water-content: 31.38%
366–381	2.1	loss of molecular water	
525–538	2.35	dehydroxylation	
752–753	25.44	decomposition of Al-Fe-sulphate	
994–995	>6.78	decomposition of Mg-sulphate, total SO_3-content: >32.22%	

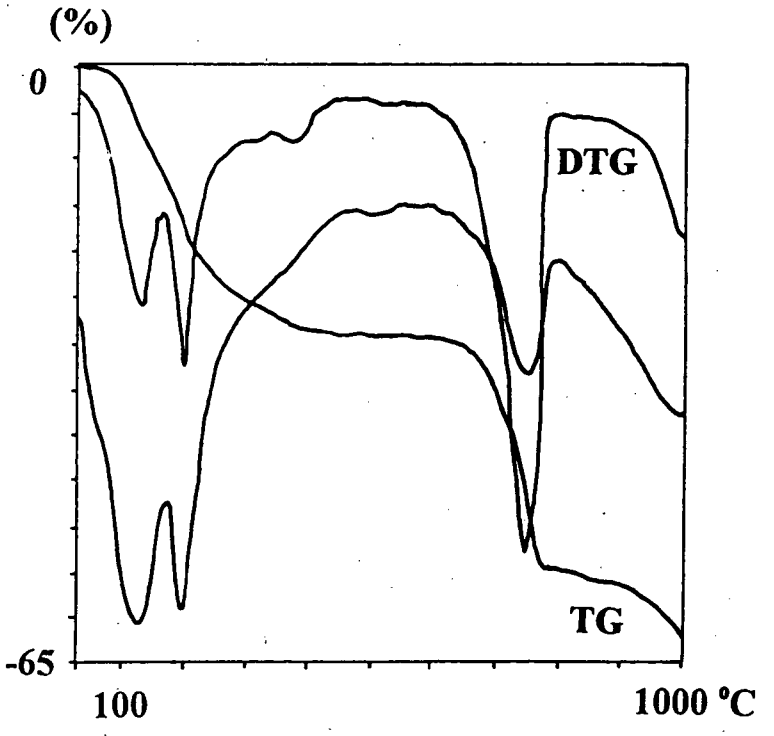

Fig. 14. Thermoanalytical curves of fibroferrite, copiapite and gypsum from Rudabánya.

A very small amount of alumina and a significant amount of magnesium was detected by the wet chemical analysis of the specimen. Magnesiocopiapite could be the other dominant sulphate mineral, which accompanies fibroferrite. The coexistence of these two

phases was confirmed by the crystal morphology, because on SEM images copiapite forms diverse, 5–15 μm-sized grains or lamellae, whereas fibroferrite appears in 50–200 μm-sized, fibrous aggregates (Fig. 15).

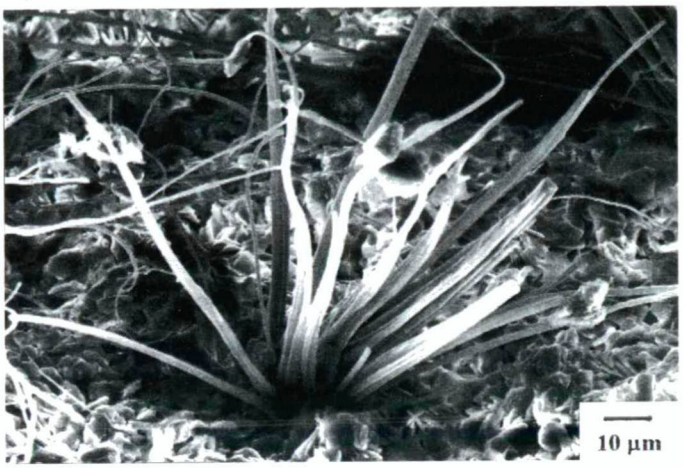

Fig. 15. Fibroferrite, needle-like crystals, Rudabánya, Vilmos mine. Scanning electron micrograph

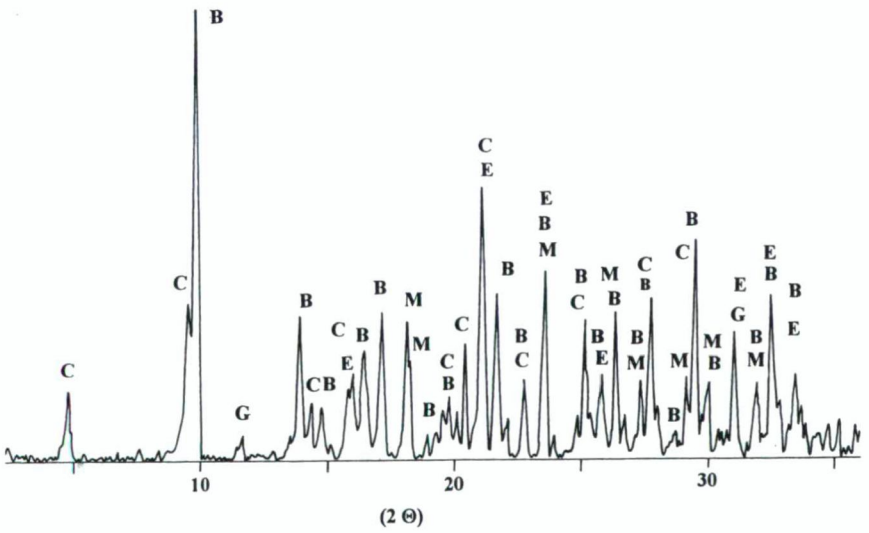

Fig. 16. X-ray powder diffractogram of botryogen, copiapite, epsomite, gypsum and melanterite, Rudabánya, Andrássy III mine. MÁFI, Budapest

Botryogen $MgFe(SO_4)_2(OH) \cdot 7H_2O$

It was found in the open pit of the Andrássy III mine. Yellow and orange spots of a few cm^2 size appeared on the wall of the outcrop, forming incrustations on the disseminated sulphides (HOM 23953). By the result of the XRD test of these orange segregations (H9), the dominant phase is botryogen, which is accompanied in decreasing order by epsomite, melanterite, gypsum and copiapite (by the XRD the most part of the yellow spots consist copiapite). 13 reflections of botryogen were detected on the X-ray patterns (Fig. 16). The diffractogram best corresponds to zincobotryogen:

Rudabánya		botryogen, 17-157		zincobotryogen, 34-186	
8.928	100	8.87	100	8.963	100
6.343	30	6.29	60	6.354	60
5.161	30	5.11	60	5.166	75
3.029	45	2.998	80	3.027	60

A 1.42 % zinc-content was detected by the chemical analysis of the specimen, indicating that the mineral could be identified as botryogen, even though this specimen contains five minerals. If the five minerals appeared in equal proportions, then the ZnO-content would be 0.8%. Therefore both by the chemical analysis and by the XRD test it is sure that the dominant mineral is botryogen. If it occurs in more than 35%, then the analysed phase is zincobotryogen; if it is less, then this is a zinc-bearing botryogen. While we cannot establish the proportions of the phases then it could be named as zinc-bearing botryogen. Further analyses would be necessary to answer this question. The results of the chemical analysis are the following:

ZnO	1.42
MnO	0.77
FeO	15.95
MgO	6.83
CuO	0.24
SO_3	33.67
PO_4	1.50
K_2O	0.17
SiO_2	0.13
H_2O	[35.60]
Σ	96.28

Analyst: Mrs. I. BALLÓK (MÁFI), Method: ICP, []: the H_2O-content was determined by thermoanalysis.

Mosaic pattern can be observed on SEM images, indicating the desiccation of the surface of the incrustations.

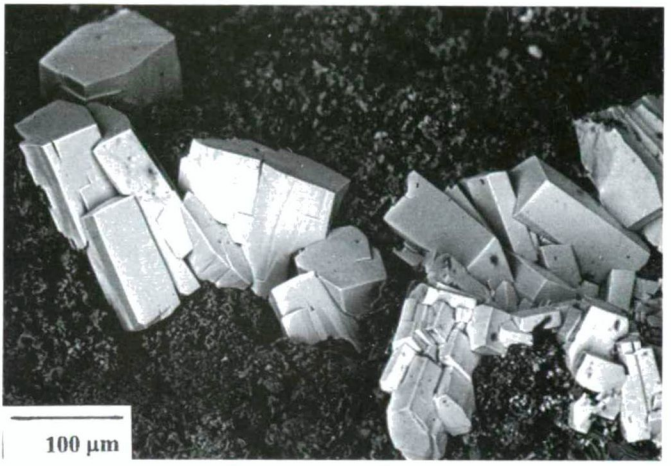

Fig. 17. Linarite crystals, Rudabánya, Adolf mine. Scanning electron micrograph.

Linarite $CuPbSO_4(OH)_2$

This is a member of the sulphate-rich secondary mineral paragenesis in the Adolf mine. It usually forms 1–2 mm thick, light-blue seams in the earthy masses of smithsonite (HOM 23315). 1–3 mm-sized aggregates of tabular or prismatic, sky-blue crystals, and radiated-bunched aggregations that occur in the cracks (Fig. 17). Oriented intergrowths of 3–6 crystals appears frequently. 16 reflections of linarite can be detected on the X-ray patterns, which correspond to the data of the JCPDS card 4-598 (Table 5). Pb, Cu and S were detected by EDX. In addition to smithsonite, the following minerals can be found in the closest environment: goethite, brochantite, malachite, aurichalcite, jarosite, cinnabar and cerussite.

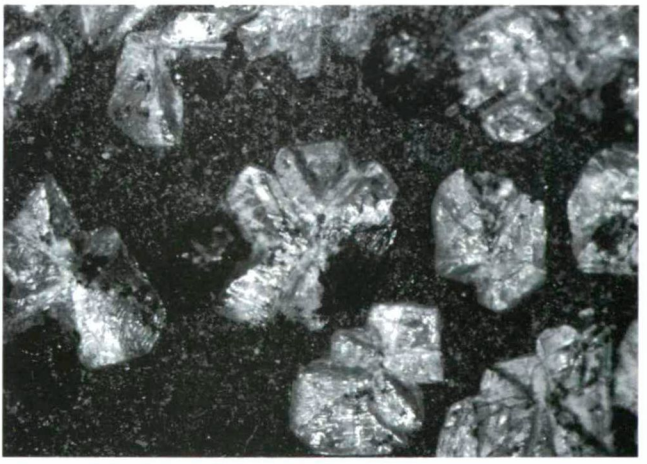

Fig. 18. Posnjakite, tabular crystals, Rudabánya. Width of the picture 0.9 cm.

Posnjakite $Cu_4SO_4(OH)_6 \cdot H_2O$

It is known only from a museum specimen (HOM 18599) that originated from a not exactly identified area of the open pit. Sky-blue, 1–2 mm pseudohexagonal, thin-tabular single or rarely grouped crystals of this mineral occur on the surface of the sample, which contains disseminated pyrite and marcasite (Fig. 18). The crystals are associated with sulphide-bearing patches, so they formed by the weathering of sulphides. The presence of posnjakite was confirmed not only by the morphology of the crystals, but also by X-ray patterns (Table 6) and EDX tests that showed copper and sulphur. Because of the overlapping peaks of posnjakite and other phases (pyrite, quartz, goethite), it could be identified only by the peaks: 100 at 6.95 (6.94) Å and the 10 at 3.45 (3.47) Å (the data of the JCPDS card 20-364 are listed in the brackets).

Slavíkite $NaMg_2Fe_5(SO_4)_7(OH)_6 \cdot 33H_2O$

In Hungary, first it was found in the open pit of the Andrássy III. mine (HOM 23773). It occurs rarely, forming yellowish-green, crust-like aggregates, which in fresh state are soft and after desiccation become hard. Three sulphate phases were detected by XRD obtained from these crusts (A72a). They include slavíkite, melanterite and a small amount of gypsum. 22 reflections of slavíkite appeared on the X-ray patterns. The largest, not overlapped ones were: the 100 at 8.99 (9.04) Å and the five 80-s at 11.6 (11.7), 5.81 (5.83), 5.40 (5.41), 4.19 (4.21) and 3.45 (3.47) Å d values (the data of the JCPDS card 20-679 are listed in the brackets). Slavíkite occurs in 0.1–0.5 mm-sized, hexagonal tabular crystals, on which the {0001} is well developed. On SEM images, the tabular crystals are rather cracked because of water losses (Fig. 19.). Fe, Mg and S and in traces Cu and Na were detected by EDX.

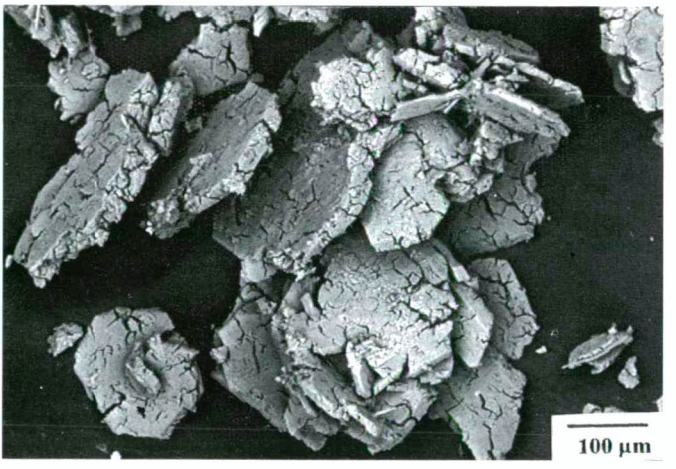

Fig. 19. Slavíkite, tabular crystals, Rudabánya, Andrássy III mine. Scanning electron micrograph.

Serpierite $Ca(Cu,Zn)_4(SO_4)_2(OH)_6 \cdot 3H_2O$

It was found in the cavities of a museum specimen (HOM 11413) that originated from an unknown point of the open pit. By the paragenesis, this specimen belongs to the zone of

oxidation. An interesting secondary mineral assemblage occurs on the black crusts of the cavities of the limonite ore that consists of tennantite (by XRD and EDX). Still not fully identified, blue and green, botryoidal incrustations and blue radially-fibrous aggregates have been formed by the weathering of tennantite (Fig. 20).

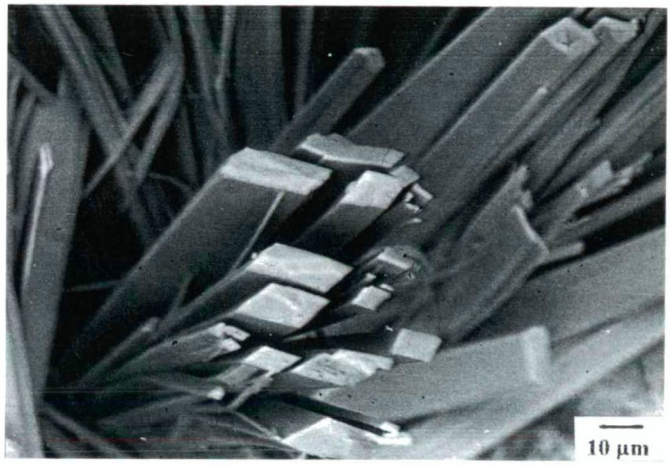

Fig. 20. Serpierite spray, Rudabánya. Scanning electron micrograph.

These 1–2 mm-sized, radiating aggregates of sky-blue, lath-shaped, columnar crystals consist of serpierite, according to XRD and EDX tests. 9 reflections of serpierite appear on the X-ray patterns; among these, the peak at 2.16 Å is the only one that is characteristic for serpierite but not for devilline, which has a similar diffractogram (Table 7). The EDX test detected sulphur and both copper and zinc. According to a semi-quantitative microprobe test the Cu:Zn ratio is 3:1, which compared with the published data (HÖLZEL, 1992) indicates a Zn-poor serpierite.

Martonyi

A small amount of secondary sulphates occurs in the material of the abandoned open pit. Compared to Rudabánya, this deposit is much poorer in sulphides. *Gypsum* forms 1–2 mm-sized, acicular aggregates and the *jarosite* appears in yellow, dust-like tarnish, or earthy masses. *Posnjakite* rarely found as skye-blue, fine-grained aggregates or minute (less than 1 mm) columnar crystals according to XRD (A. Roberts, Geol. Survey of Canada, oral communication) and EDX tests (HOM 24153).

Telkibánya

The sulphate minerals of the deposit were described by SZÉKY-FUX (1970) and SZAKÁLL *et al.* (1994).

3.2. SECONDARY SULPHATES IN MAGMATITES (IN THE ENVIRONMENT OF DISSEMINATED SULPHIDES)

Among the secondary sulphates – except for a few exceptions –, only gypsum and jarosite occur in magmatic rocks, but they are much more widespread that it was known before. According to our data, jarosite and gypsum appear in the surroundings of nearly all pyrite and/or marcasite disseminations, veins or crusts (see Table 1.). Both sulphates formed by the weathering of iron sulphides and potassium- or calcium-rich silicates. They appear nearly by the same origin in hydroquartzites formed by the postvolcanic activity of magmatites, first of all in the Mátra and Tokaj Mountains. *Gypsum* usually forms 1–3 mm long acicular crystals and aggregates, while *jarosite* appears in yellow, dust-like tarnishes the apparently as common occurrence of jarosite may be related to the fact that it usually forms together with goethite, or it turns into goethite by weathering.

The sulphate parageneses that are different form the above listed ones and were instrumentally tested, are the following:

– *Szomolnokite* was detected by XRD and EDX tests from weathering products of the quartz inclusions disseminated with pyrite, in the andesite quarry of Kisnána.

– *Jarosite, gypsum* and *halotrichite* and first of all goethite formed by weathering of the surface of the andesite disseminated with pyrite, in the abandoned andesite quarry near the Rudolf-tanya, Parádsasvár.

– During storage, *copiapite, rozenite* and *szomolnokite* formed by weathering of marcasite on the surface of the (usually dark-grey coloured) limnoquartzite specimens from Rátka (Hercegköves quarry), containing disseminated marcasite (XRD G54).

– Andesite of the quarry of Kopasz Hill, Tállya frequently contains disseminated pyrite along fissures. *Gypsum*, formed by weathering of pyrite was mentioned by TOKODY (1965). White, yellowish-white blooms of Mg-sulphates – *hexahydrite, pickeringite* and *epsomite* appear by weathering on the surface of pyrite-bearing andesite (XRD E16, G65).

3.3. SECONDARY SULPHATES IN SEDIMENTARY ROCKS (IN THE ENVIRONMENT OF DISSEMINATED SULPHIDES)

Gypsum and *jarosite* appear commonly in sedimentary rocks. They occur in any kinds of sedimentary rocks that contain disseminated pyrite and/or marcasite; their formation is similar to those ones, which have been formed in magmatic rocks.

3.3.1. SEDIMENTARY MANGANESE DEPOSITS

Úrkút, Eplény

Gypsum occurs commonly in the clay that covers the manganese ore bodies (KOCH, 1985). Rarely we found earthy, yellow tarnishes that consist of *jarosite* (HOM 22973).

3.3.2. SEDIMENTARY URANIUM DEPOSITS AND URANIUM INDICATIONS

Kővágószőlős

According to KOCH (1985), the recent paragenesis of the walls of the mine workings consists of uranopilite, zippeite and gypsum (see Table 1.). We detected *thenardite* by XRD tests (C83, L81), (HOM 21704); it forms 1–4 cm-sized, white, stalactite-like aggregations. *Gypsum* appears in similar form on the walls of the mine workings, together with aragonite or rarely with calcite. *Jarosite* occurs rarely in yellow, dust-like tarnish. By XRD and EDX, we also detected *zippeite,* but a more detailed investigation would be necessary, considering the substitution possibilities in the zippeite group.

Nagyvisnyó

The secondary sulphates (anglesite, gypsum, jarosite) of this uranium indication, occurring in sandstone, were summarized by VINCZE & SELMECZINÉ (1976–1980).

3.3.3. BAUXITE DEPOSITS

Extremely abundant – iron sulphate-rich – parageneses were formed by epigene and hypergene processes in the Hungarian bauxite deposits (see Table 1.). They were summarized by BÁRDOSSY (1977). We can complete them with *alunogen*, which was found in the dump of the Nagyegyháza deposit, forming white, recent incrustations.

3.3.4. PHOSPHATE INDICATIONS

Jarosite, which occurs together with Al- and Fe-phosphates in the phosphate indications of the Uppony Mountains, was described by ELSHOLTZ, SELMECZINÉ ANTAL & SELMECZI (1969) and SELMECZINÉ (1973).

3.3.5. COAL BEDS

Variegated, mineral-rich sulphate parageneses are known from coal beds (KOCH, 1985). The sulphate minerals appear directly in the coal, on the walls of the mine workings and also on the burning dumps. The largest variety of these minerals was formed on the slowly burning dumps, in the so-called fumarole phase, when they are segregated from vapour. Sulphur and sal ammoniac occur frequently, accompanying the sulphates. In the surroundings of the fumaroles, the loose dump is cemented commonly with „seams" of sulphates (and sulphur and sal ammoniac), with thicknesses up to 1–2 dm. The largest crystals and incrustations are formed on the exhaust holes of the fumaroles. The characteristic sulphate parageneses (except for gypsum and jarosite, which occur everywhere) vary by the mountain ranges.

Tschermigite and aluminite are the characteristic minerals of the Eocene coal beds of the Gerecse Mountains. Epsomite and halotrichite appear here in the mine workings, and the most frequent minerals of the dumps are alunogen, halotrichite and rozenite (see Table 1).

On the dump of the coal beds near Tatabánya, rozenite and melanterite occur frequently.

The coal mine workings and the dumps in the Mecsek Mountains contain alunogen, halotrichite, rozenite and melanterite.

Na-sulphates such as thenardite and sodium alum occur usually in Bátonyterenye (Nógrád coal basin).

Ammonium sulphates appear commonly in the beds of the Borsod coal basin. Species-rich parageneses were found by us here both in the mine workings (Egercsehi) and on the dumps (Ormosbánya, Miskolc-Lyukóbánya, Múcsony, Radostyán). We have no information about any other paragenesis related to coal beds in the Carpathian Basin, that contains as many secondary sulphate species as this one.

Sopron-Brennbergbánya

Gypsum and *jarosite* were detected in small amount from the burned dump of the Hermes shaft. *Rozenite* and *melanterite* were also found on the surface of marcasite aggregates, forming curved fibres or light-green tarnish.

Komló

The sulphate minerals of the coal beds of the Mecsek Mountains were summarized by NOSKE-FAZEKAS & NAGY-MELLES (1969). We can complete the list with the observations of *alunogen* which was found in large amount on the dump of the Komló-Dávidföld mine (XRD C217, C218). Alunogen forms here white, yellowish-white, 1–2 cm thick crusts on the burned aleurolite.

Pécs-Vasas

Various occurrence of *gypsum* was observed in the material of the Vasas open pit. It occurs both in the cracks of the coal and in the enclosing layers, forming a few mm-sized crystals. Yellow, dust-like aggregations of *jarosite* are also common.

Tokod

The sulphate minerals, occurring in the enclosing sedimentary rocks of the coal bed, were summarized by PAPP (1990).

Dorog

Jarosite and *gypsum* appear in a small amount on the old dumps in the Anna Valley.

Esztergom, Lencse Hill

The most commonly occurring sulphates of the dumps of the Lencse Hill mine are *gypsum, jarosite* and *mascagnite*. Jarosite occurs with especially variegated habit, while pyrite and/or marcasite concretions and veinlets appear frequently in the whole coal bed. They can be found both in the coal and in the enclosing rocks, forming dissemination, veins and incrustations. The fossils (shells and snails) that occur in these sedimentary rocks were fully recrystallized into marcasite; therefore, the weathered specimens, consisting of jarosite and goethite are especially remarkable specimens.

Gypsum and mascagnite were found in especially large amounts, together with sulphur on the old, burned dump of the Lencse Hill mine, where they form 1–2 dm thick crusts. *Gypsum* was found in aggregates of a few mm long crystals. *Mascagnite* was detected by

the XRD diffractogram (G391) in greyish-white, botryoidal aggregates, accompanied by sulphur.

Bajna

The following sulphates are known from the brown coal open pit of Hantos-puszta. *Gypsum* aggregates occur in extremely variegated habit, size (the largest ones are 40–50 cm in diameter) and colour (colourless, white, grey, yellow, black) in the enclosing clay and sand layers. *Jarosite* forms dust-like dissemination, 2–3 cm-sized massive aggregates or 1–2 mm thick crusts on the surface of the quite widespread marcasite concretions. *Rozenite* appears commonly in white fibres on the weathered surface of the marcasite-pyrite concretions.

Sárisáp

Gypsum and *jarosite* were detected from the enclosing sedimentary rocks.

Mogyorósbánya

Gypsum and *jarosite* occur frequently in the workings of the brown coal mine. The most interesting mineral here is *tschermigite*, which appears rarely, forming fibrous, 0.5–1 cm thick, white, vitreous veinlets. This appearance is quite similar to an other one, which was found earlier in Tokod. The presence of tschermigite was confirmed by X-ray patterns (C60). Nearly all reflections of the JCPDS card 7-22 appeared on this diffractogram. The largest reflections were detected at the following d values: 100 – 4.32 (4.32), 80 – 4.08 (4.08), 75 – 3.26 (3.27) Å.

Várpalota

The following sulphates were detected from the specimens, obtained from the dump of the Inota-puszta shaft. *Jarosite* and *gypsum* are the most frequent sulphates, they occur in dust-like disseminations or in 1–3 mm-sized aggregates. White, yellowish-white incrustations of *anhydrite* and *mascagnite* appear rarely, as confirmed by X-ray patterns (C53). 36 reflections of mascagnite were found in the diffractogram. In SEM images, the mascagnite-bearing crusts consist of dense intergrowths of fine-lamellar crystals (HOM 19628).

Bicske, Csordakút

The secondary sulphate minerals of the coal bed were described by WEISZBURG (1981).

Tatabánya

Information about the sulphate minerals related to the coal beds of Tatabánya were summarized by KOCH (1985). The formerly burned dumps of the coal mines in the surroundings of the town contain a small amount of sulphates. The widespread ones are *gypsum* and *jarosite*, which occur both in the coal and in the enclosing rocks. Gypsum occurs in smaller amounts than on the other dumps, but jarosite has a quite variable appearance. It forms dust-like disseminations, incrustations, pseudomorphs after pyrite and marcasite and also after fossils, which have been recrystallized into an iron sulphide. White, fibrous aggregates of *rozenite* with a few mm size were found commonly on some dumps, on the surface of the very frequent marcasite-pyrite concretions (XRD C220).

Verőce, Katalin Valley

Jarosite and *gypsum* occurred in a small amount on the dump of the lignite mine (XRD C91) abandoned long ago.

Bátonyterenye

The following sulphate mineral assemblage was detected from the formerly burned dump of the Szoros-patak shaft: *gypsum, jarosite, pickeringite, sodium alum, thenardite.*

Among these, gypsum and jarosite are the most frequent ones; they form few mm-sized, acicular aggregates and yellowish, dust-like segregations, respectively. Thenardite occurs in white, flour-like disseminations. Pickeringite is a characteristic sulphate of the white incrustations.

Sodium alum $NaAl(SO_4)_2 . 12 H_2O$

Sodium alum is known from Hungary only from this deposit. It was detected from white crusts and fibrous aggregates, together with a small amount of gypsum and with quartz grains, which were probably mixed with the sulphates.

18 reflections of sodium alum were detected on the X-ray powder patterns (V96) (Table 8.). The three largest reflections appeared at the following d values: the 100 at 4.24 (4.23); the 50 at 3.66 (3.65); the 40 at 3.96 (3.98) Å. (The corresponding values of the JCPDS card 1-397 are in the brackets). Na, Al and S were detected by EDX.

Gypsum and *jarosite* occur in a small amount on the dump of the Kányás-puszta shaft. Using EDX, we found minerals of the jarosite group that are uncharacteristic for jarosite (they did not contain potassium). In their closest environment, portlandite and a small amount of brucite were found (SZAKÁLL, 1989).

Visonta

Only two sulphate minerals – *gypsum* and *jarosite* – were found in these large lignite open pits, probably because of the small number of collected specimens. Jarosite occurred only in minute amounts, while gypsum usually formed cm-sized, rose-shaped aggregates, but 25–30 cm-sized ones appeared, too. Individual crystals occur rarely, but among them, a remarkable skeletal crystal of 4 cm size was found with perfect edges.

Miskolc-Lyukóbánya

An extremely large variety of sulphate efflorescences have been formed between 1980 and 1990 on the slowly burning dumps of the coal beds. The following data were obtained by instrumental tests (XRD, EDX, SEM and thermal analysis). *Gypsum* occurred with great frequency, forming fibrous or flour-like aggregates. *Hexahydrite* appeared in white, flour-like tarnish or in fibrous aggregations. *Anhydrite* was detected in a small amount, together with gypsum by XRD tests. *Alunogen*, accompanying *millosevichite* and *voltaite*, appeared in white and greyish-white crusts. *Mascagnite* occurred in white, yellowish-white crusts, together – by XRD diffractogram – with a small amount of *koktaite* and gypsum. *Rozenite* was found in white, dust-like aggregates.

Mascagnite, *koktaite* and *millosevichite* were first detected in Hungary from this deposit; therefore, the related investigations will be outlined here. The sulphate paragenesis was accompanied by a large amount of sulphur, less commonly by sal ammoniac, goethite and hematite, rarely by portlandite and albite.

Mascagnite $(NH_4)_2SO_4$ and koktaite $(NH_4)_2Ca(SO_4)_2 \cdot H_2O$

The dirty-white, yellowish-brown, or grey porous crusts of *mascagnite* occurred quite commonly. 1–2 mm-sized spherules of white, lamellar crystals were also found. According to SEM images, these crusts had lamellar or cellular structure (Fig. 21).

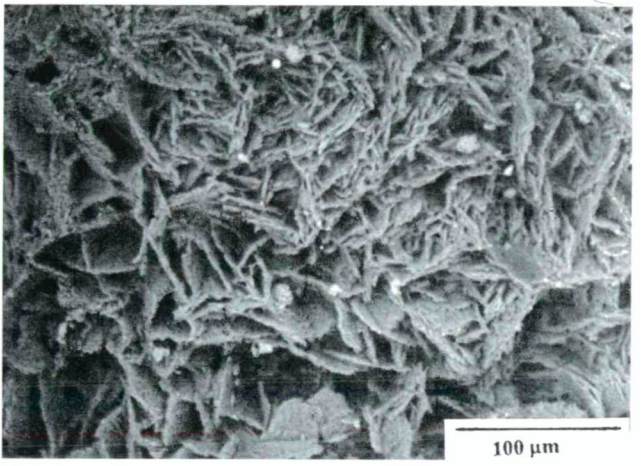

Fig. 21. Mascagnite, porous crusts, Miskolc-Lyukóbánya. Scanning electron micrograph.

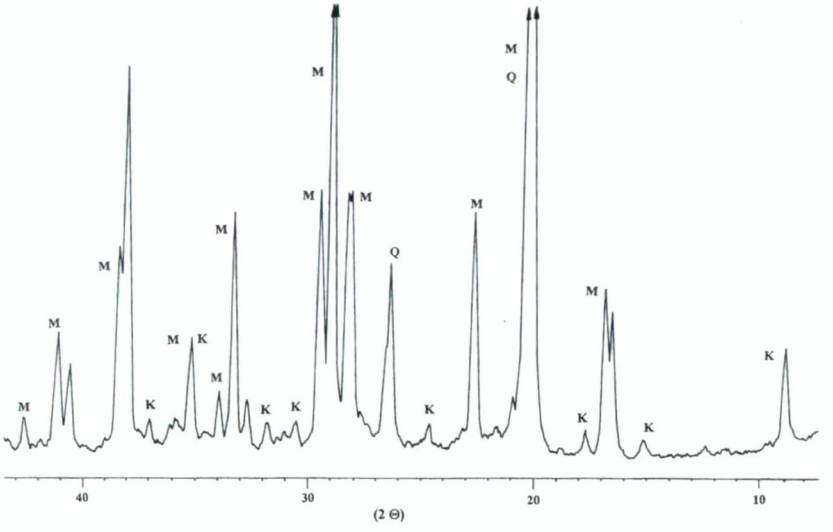

Fig. 22. X-ray powder diffractogram of mascagnite and koktaite, Miskolc-Lyukóbánya. MÁFI, Budapest

56 appreciable reflections appeared on the X-ray patterns (Fig. 22). 19 of these are related to mascagnite. The two largest peaks of quartz and the largest ones of goethite could be identified clearly. 12 reflections of koktaite could be detected; 7 of these –

including the 100 at 10.15 Å (9.83) and the 65 at 3.31 Å (3.30) – are not overlapped (the data of the JCPDS card are listed in the brackets). By the diffractogram, it could be brushite, and/or a small amount of gypsum.

The result of a wet chemical analysis of the specimen, which contains several phases, is the following (compared to the composition of mascagnite and koktaite, according to HÖLZEL, 1992):

	Miskolc-Lyukóbánya	mascagnite	koktaite
SiO_2	11.7		
Fe_2O_3	3.3		
CaO	1.4		19.59
K_2O	1.2		
$(NH_4)_2O$	14	39.41	18.17
H_2O			6.29
SO_3	56.3	60.59	55.94
Σ		100	99.99

Analyst: Mrs. I. SOHA (MÁFI).

Nine endothermic reactions were indicated with weight losses (Fig. 23.) by the thermal analysis of a sample that weighed 100.9 mg and was heated up to 1000 °C. Six reactions of mascagnite were determined by COCCO (1952). Only two reactions were observed on the curve of the thermal analysis of synthetic $(NH_4)_2SO_4$. The data for synthetic $(NH_4)_2SO_4$ were also published by CVETKOV & VALYASHSCIKHINA (1955).

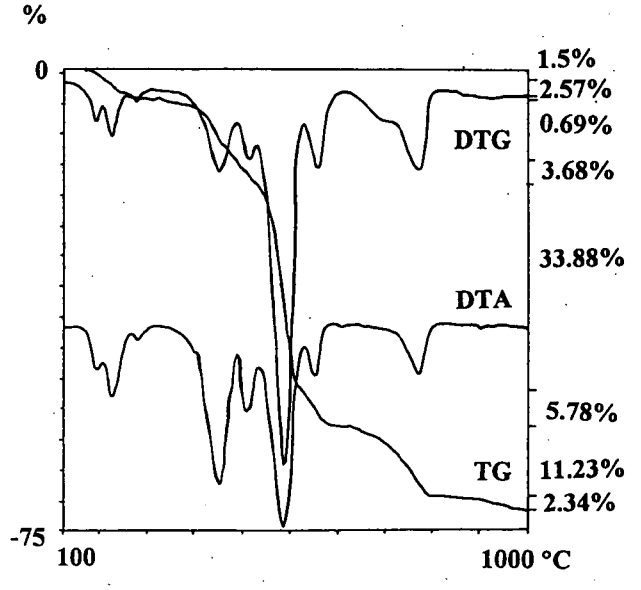

Fig. 23. Thermoanalytical curves of mascagnite and koktaite from Miskolc-Lyukóbánya.

specimen	Cocco (1952) natural	synthetic	Cvetkov & Valyashscikhina(1955) synthetic
92–93 °C			
126 °C			
179 °C	180 °C		
351–354 °C	400 °C	368 °C	350 °C
416 °C	425 °C		410 °C
488 °C	455 °C	502 °C	
556–585 °C	590 °C		555 °C
769–774 °C	790 °C		
948 °C			

The measured weight loss values:

specimen	%	reagent	%
93 °C	1.5		
126 °C	2.57		
179 °C	0.69		
351–354 °C	9.69	368 °C	15.71
416 °C	3.86		
488 °C	33.88	502 °C	77.13
556–558 °C	5.78		
769–774 °C	11.23		
(948 °C)	2.34		

From the above data, the reactions at 352 °C and 556 °C are related to mascagnite. The measured weight losses do not fully agree with the presumed reactions.

1. $(NH_4)_2SO_4 \rightarrow NH_3 + NH_4HSO_4$ – weight loss: 12.9%
2. $NH_4HSO_4 \rightarrow NH_3 + H_2O + SO_3$ – weight loss: 87.1%

The facts, that the measured ignition losses of the specimen are only 72.59% instead of 100%, and that then are further 7 thermal reactions; plus the results of the wet chemical analysis (in accordance with the XRD test), show that the specimen also contains minerals other than mascagnite. If the total CaO-content of the wet chemical analysis were calculated for this mineral, then the specimen would contain probably 7% of koktaite. By XRD diffractogram, the SiO_2-content is associated with quartz, the Fe-content with goethite.

Millosevichite $(Al,Fe)_2(SO_4)_3$

It was detected together with alunogen and/or voltaite using XRD and EDX methods. It forms massive, white, greyish-white crusts (HOM 13886). Three phases could be distinguished on SEM images. *Alunogen* was found in 10–30 μm-sized, tabular crystals (containing Al and S by EDX), *millosevichite* (containing Fe, Al and S) occurred in 15–30 μm long, columnar crystals (Fig. 24.), and *voltaite* was characterized by 10–15 μm-sized, poorly developed crystals (with K-, Fe-, Al- and S-content). 32 reflections of voltaite occurred on the G346 diffractogram, and millosevichite was detected only in a small

amount. The largest three reflections of voltaite were at: the 100 – 3.40 (3.39), the 80 – 3.54 (3.53), and the 60 – 5.56 (5.55) Å d values (the data of the JCPDS card 20-1388 are listed in the brackets).

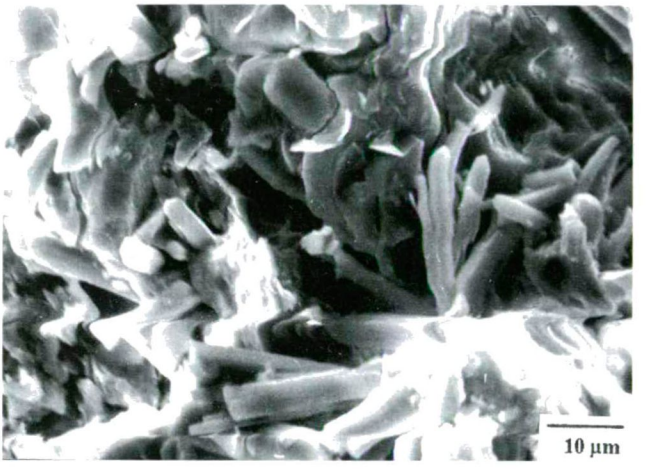

Fig. 24. Millosevichite, columnar crystals with alunogen, Miskolc-Lyukóbánya. Scanning electron micrograph.

One of the dominant phases on the E117 diffractogram is millosevichite, which occurs there together with alunogen. 21 reflections of millosevichite could be detected on the X-ray patterns (Fig. 25.); the largest ones are: the 100 at 3.50 (3.49), the 35 at 2.91 (2.91), and the 30 at 5.81 (5.82) Å d values. A few reflections of an indefinable phase occur together with alunogen on this diffractogram.

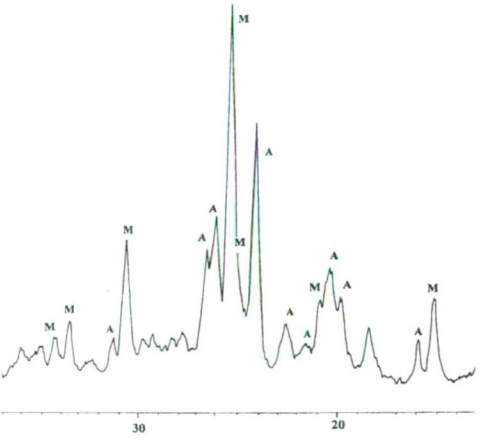

Fig. 25. X-ray powder diffractogram of millosevichite and alunogen, Miskolc-Lyukóbánya. Dept. of Mineralogy, ELTE, Budapest

Ormosbánya

The following minerals were detected from the specimens of the formerly burned dump, near the Ormos shaft, and collected in the period between 1985 and 1990 (XRD E289-296). *Sal ammoniac* appeared most frequently, forming 1–2 cm thick, coarse grained crusts, or flour-like aggregates. Yellowish-white tarnishes of *mascagnite*, *halotrichite*, and *hexahydrite* were found in smaller amounts. *Letovicite* which is only known from here in Hungary, occurred also in minute amounts, together with sal ammoniac and mascagnite. A Ba- and S-bearing phase which appeared in a few μm-sized grains, was detected by EDX; it is probably *barite*.

Letovicite $(NH_4)_3H(SO_4)2$

It was detected together with sal ammoniac and mascagnite in the material which was collected on the dump. It formed white, fine-grained aggregations on the surface of the 1–2 mm long crystals of sal ammoniac, or among the mascagnite aggregates (HOM 17288). In SEM images, letovicite also forms 10–15 μm thick crusts, together with mascagnite on the crystals of the sal ammoniac (Fig. 26.). These crusts are porous and have a rough-fibrous structure on the surface of the fracture. Letovicite was identified by X-ray powder patterns. 9 reflections of letovicite appeared without overlapping on the diffractogram E289 (Table 9.), in addition to the reflections of the much more common sal ammoniac and mascagnite. The thermal analysis indicated that the dominant phase is sal ammoniac, but small endothermic reactions between 600 and 700 °C point to the decomposition of the sulphates mascagnite and letovicite.

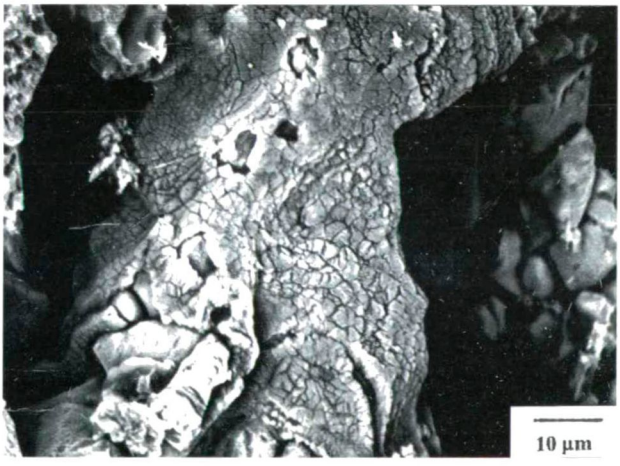

Fig. 26. Letovicite, crusts with sal ammoniac, Ormosbánya. Scanning electron micrograph.

Egercsehi

An interesting sulphate mineral assemblage was collected in the abandoned workings of the mine in the period 1986–1989. The sulphate segregations appeared in a 20–30 m long area on the timbers and in their closest surroundings. The white, yellowish-white crusts and stalactitic aggregates covered an area of a few dm^2 size. By our observations (XRD: E304-307, A226-228, L120, L121), the paragenesis consists of the following minerals: *alunogen* is the main sulphate mineral (forming white, yellowish-white crusts

and tabular crystals) the accompanying minerals are *tamarugite* (in microscopic aggregates, in dense intergrowths with alunogen), *copiapite* (bright-yellow tarnishes and globular aggregates), *halotrichite* (white, acicular aggregates with silky lustre), *melanterite* (light-green crystals of 1–2 mm size and incrustations), and *rozenite* (formed by the decomposition of melanterite and after the disaggregation into a white dust). Here we describe in detail tamarugite, because it was first found in Hungary in Egercsehi.

Tamarugite $NaAl(SO_4)_2 . 6H_2O$

It was usually found in small amounts on the white and yellowish-white incrustations of lamellar crystals of alunogen. The white, 0.2–0.8 mm-sized, thin-tabular alunogen crystals form loose aggregations that look like stacks of cards. In SEM images, the tabular crystals are more often grouped into fan-shaped aggregates (HOM 13075). Tamarugite usually occurs together with these tabular crystals, and only rarely forms self-contained aggregates of a few μm size.

The diffractogram of the crust-like segregations (E307) proved the presence of tamarugite together with the dominant alunogen (Fig. 27.). Nearly 40 reflections of tamarugite appeared on the diffractogram. The peaks with 100 and 60% intensities appear definitely at 4.22 (4.22) and 3.64 (3.65) Å d values. But the 80 peak is uncertain, because it is overlapped by the reflection of the peak with 100 intensity. The result of the wet chemical analysis of the specimen, shows that it consists principally of alunogen; the data are shown below, in comparison with the composition of tamarugite and alunogen, as given by HÖLZEL (1992).

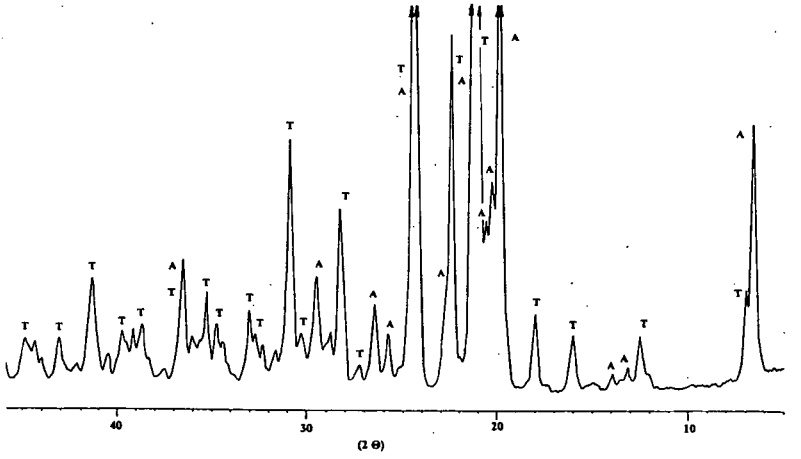

Fig. 27. X-ray powder diffractogram of tamarugite and alunogen, Egercsehi. Dept. of Mineralogy, ELTE, Budapest

	Egercsehi	tamarugite (Hölzel, 1992)	alunogen (Hölzel, 1992)
Al_2O_3	15.56	14.48	14.9
Na_2O	1.03	9.04	
H_2O	42.61	30.9	50.01
SO_3	38.75	45.66	35.09
Σ	97.95	100.12	100

Analyst: Mrs. I. SOHA (MÁFI).

It can be seen from this analysis, that tamarugite appears in this sulphate segregation only in a small amount, accompanied by another mineral (alunogen, according to XRD).

Results of a thermal analysis from a sample that weighed 104.6 mg (Fig. 28.) show:

[°C]	[%]
126	7.65
142	23.69
281	7.34
320	3.93
811	32.56

We did not find any publications about the thermal analysis of tamarugite; however by general experience, the first four reactions could be considered as water losses, and the last one as the decomposition of SO_3. Based on this, the measured water-content was 42.61%, the SO_3 content 32.56%, the ignition losses were 75.65% (up to 1000 °C). Presumably, part of the SO_3-content (about the 1/4) is related to the sodium and will only decompose above 1000 °C. By the water-step proportions, the mineral has 5–5.5 mol water-content (or an integral multiple of that). For comparison, the thermal analysis data of alunogen are listed as follows:

COCCO	DUBANSKY	TODOR	17.5 mol water	theoretical	the specimen with tamarugite	17–18 mol water
°C	°C	°C	%	°C	°C	%
					126	7.65
170	175	140			142	23.69
220			47.9	47.2–48.6	281	42.61
	325	330			320	3.93
910	910	875	35.7	37-36	811	32.56

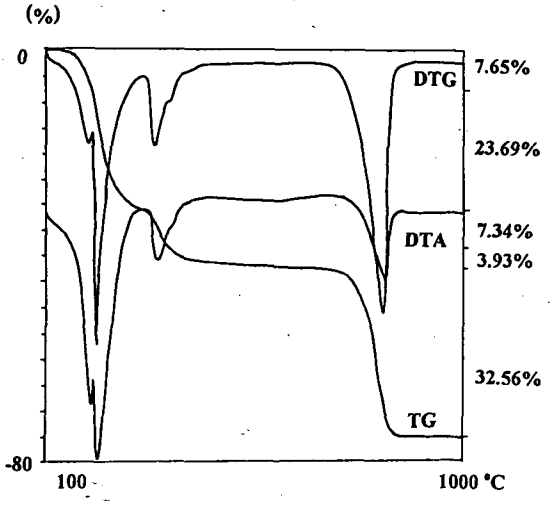

Fig. 28. Thermoanalytical curves of tamarugite and alunogen from Egercsehi.

Szarvaskő

A few sulphate minerals were found on the surface of the burned clay, west from the village, on the dump of the abandoned coal mine of the Keselyű-bérc. *Starkeyite*, *gypsum* and *jarosite* were detected from these segregations. As starkeyite is described for the first time here from Hungary, we introduce the results of the analyses in detail.

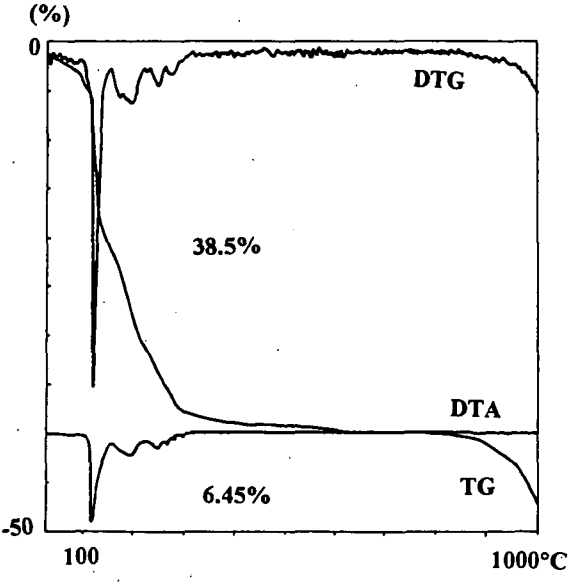

Fig. 29. Thermoanalytical curves of starkeyite from Szarvaskő.

Starkeyite $MgSO_4 . 4H_2O$

It forms snow-white, flour-like tarnish of a few mm thickness in the cracks of the burned sedimentary rocks (HOM 21708). The reactions of the thermal analysis (Fig. 29.) are:

[°C]	[%]
120.8	15.72
192.8	8.62
250.1	2.98
275.7	1.61
>1000	>5.81

The temperatures of the reactions correlate well with the reactions of the water losses (1–4.) and with the decomposition (5.) of the hydrous Mg-sulphate. By the measured water-content, the specimen consists in 77% of starkeyite. 37 reflections of starkeyite were detected on the X-ray powder patterns (L58), in accordance with the data of the JCPDS card. The largest reflections were: the two 100-s at 4.46 (4.48), and 2.94 (2.95), the 60 at 3.96 (3.95) Å d values (the data of the JCPDS card 14-632 are in the brackets). A small amount of quartz and gypsum were detected in the specimen.

Result of the wet chemical analysis:

	specimen	starkeyite (HÖLZEL, 1992)
MgO	17.4	20.95
H_2O	38.5	37.45
SO_3	38.5	41.61
Σ	94.4	100.01

Analyst: Mrs. I. SOHA (MÁFI).

Putnok

The following secondary minerals were detected from the dump of the coal mine: *alunogen, gypsum, goethite, hematite, hexahydrite, jarosite, sulphur* and *sal ammoniac* (XRD E269-275). Alunogen and hexahydrite occurred in white, dust-like efflorescences, while the gypsum formed sub-millimetric acicular aggregates.

Radostyán

White, dirty-white, massive or porous crust-like sulphate aggregates were found in 1995, on the dump of the open pit of the coal bed in Radostyán. These sulphates rarely form white crusts and bundles of dense, fibrous aggregates with silky lustre (HOM 23872). By the instrumental tests, these crusts contain the following sulphates: *alunogen, hexahydrite, gypsum, pickeringite* and *starkeyite*. Sulphur occurs in the closest surrounding of this paragenesis, which is rich in magnesium-sulphates. Pickeringite from Hungary was first found here, therefore we discuss the results in more detail.

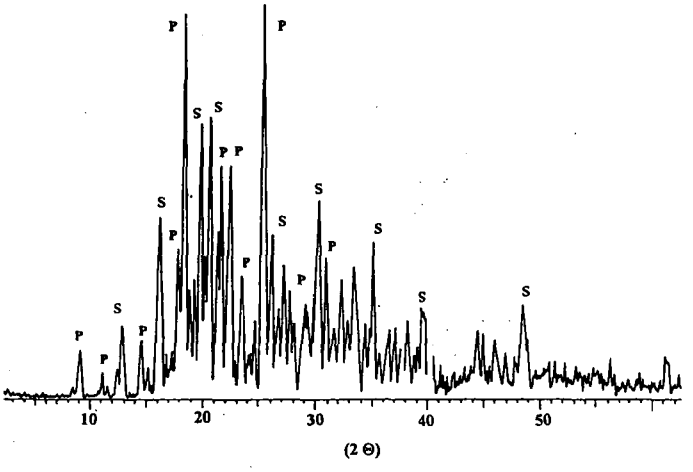

Fig. 30. X-ray powder diffractogram of pickeringite and starkeyite from Radostyán. MÁFI, Budapest

Pickeringite $MgAl_2(SO_4)_4 . 22\ H_2O$

By the X-ray diffraction patterns (G166), the following phases were detected: *pickeringite* (38 reflections), *starkeyite* (59 reflections), and a small amount of gypsum (Fig. 30.). Thermal analysis shows: ignition losses measured up to 1001.3 °C: 66.18%.

The following thermic peaks appeared on the sample that weighed 91.3 mg: 4 reactions with water losses, causing 43.7% total water loss. The sulphate-content related to Al is 15.56%, the sulphate-content related to Mg, up to 1000 °C is 6.71%, the other part decomposes above 1000 °C. Pickeringite is the possible Al-Mg sulphate by the thermal analysis (Fig. 31.), according to the sulphate-content. On the basis of the Al-sulphate steps, it appears that 55% the sample is pickeringite. The remaining water-content is connected primarily with another Mg-sulphate mineral (starkeyite). We cannot find any corresponding mineral phase for the reaction at 520 °C.

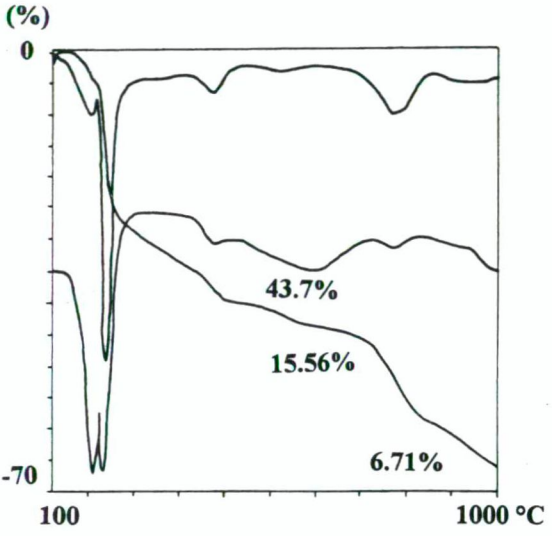

Fig. 31. Thermoanalytical curves of pickeringite and starkeyite from Radostyán.

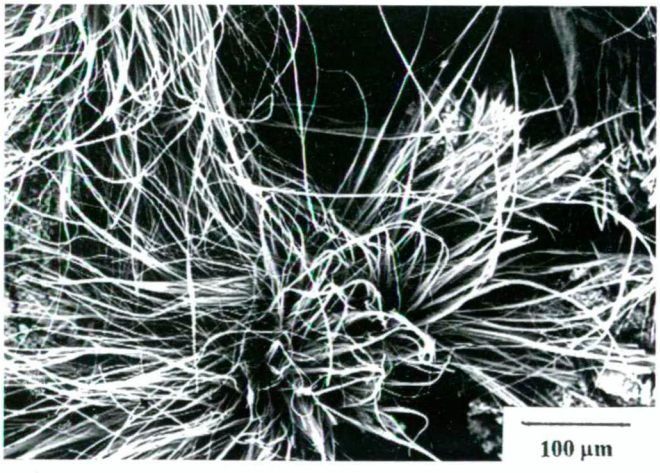

Fig. 32. Pickeringite needles, Radostyán. Scanning electron micrograph.

Hexahydrite occurs on the other two XRD diffractograms together with pickeringite. The sulphate crusts consist of these two minerals, forming white, silky, fibrous aggregates (Fig. 32.). By the result of the thermal analysis – which confirms the XRD diffractogram – the possible Mg-Al sulphate is pickeringite. The proportion of the steps points to the presence of another Mg sulphate mineral (hexahydrite). Mg, Al and S were detected by EDX.

White, flour-like efflorescences of rozenite appeared on the old, burned dump, northwest from the village (XRD E256). They include 2–4 μm-sized grains, which contain Pb by EDX tests. Unfortunately, the reflections of this phase did not appear on the X-ray powder patterns. Presumably it is anglesite(?).

Múcsony

The following minerals were detected from the burning dump of the Szeles shaft: *gypsum*, goethite, *halotrichite*, hematite, sulphur, *mascagnite* and sal ammoniac. *Sal ammoniac* forms white crusts and it occurs in places in deltoidicositetrahedral crystals of 1–2 mm size. Sulphur occurs in the largest amount, forming thick crusts and disseminations. The largest crystals of bipyramidal habit reach 1–3 mm length. Rarely thin tabular crystals and skeletal crystals appeared. Gypsum was found here in 1–2 mm long, columnar crystals, and halotrichite in fine fibres. By XRD tests, mascagnite occurs in dirty-white, crust-like segregations.

Bükkábrány

Only *gypsum* and a mineral from the *jarosite group* were detected in small amounts from this giant open pit. By EDX, K does not occur in jarosite phase, so it needs further investigations.

3.3.5. CLAY-RICH SEDIMENTARY ROCKS (RARELY WITH THE OCCURRENCE OF DISSEMINATED IRON SULPHIDES AND GOETHITE)

Gypsum is a widespread mineral in the clay. Owing to lack of space, the occurrences – which were described by KOCH (1985), and the newer ones, too – are listed in Table 1.

3.3.6. OTHER SEDIMENTARY ROCKS (IN THE ENVIRONMENT OF DISSEMINATED SULPHIDES)

The occurrences of *gypsum* and *jarosite* are well-known in numerous sedimentary rocks (sandstone, chert, limestone). Jarosite, which cements the sandstone in the surroundings of Irota and Gadna is remarkable among these (JÁMBOR, 1960).

The well-known, telethermal marcasite and pyrite of the Pannonian gravel and sand of the Keszthely Mountains occurs in large amounts in some places. An interesting sulphate mineral assemblage appears by their weathering near the surface and on museum specimens.

Rezi

Sulphate efflorescences occur on stored pyrite-marcasite-bearing specimens, which were collected in the Kotyor stream. The XRD, SEM and EDX tests of these specimens

indicate the presence of the following sulphates: *copiapite* – occurring in 1–2 mm-sized yellow aggregates; *rozenite* – in 1–2 mm long, curved fibres; *halotrichite* – forming white masses with silky lustre; *melanterite* – in green spots with glassy lustre; *gypsum* – in white, acicular aggregates, and *jarosite* – forming yellow, dust-like dissemination.

Voltaite $K_2Fe_8Al(SO_4)_{12} \cdot 18H_2O$

It was the first occurrence of voltaite in Hungary, appearing in 0.2–0.4 mm-sized, black crystals with glassy lustre (HOM 23631). The dense intergrown crystals usually form crust-like aggregates. In SEM images, the crystals have a deltoidicositetrahedral shapes (Fig. 33.). K, Fe, Mg and S were detected from these crystals by EDX. 16 reflections of voltaite were identified from the X-ray powder patterns (Table 10.), which agree well with the data of the JCPDS card 17-539.

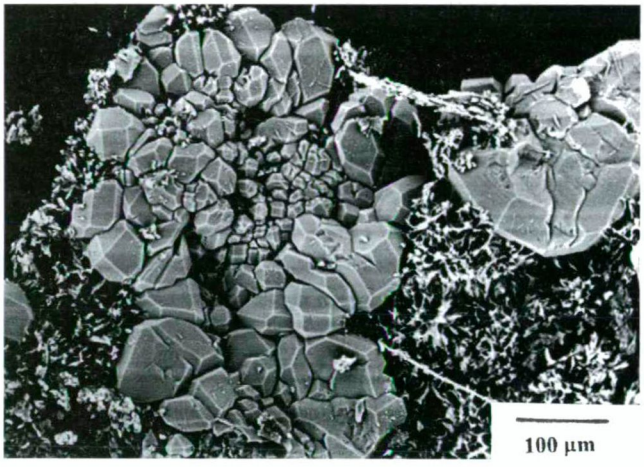

Fig. 33. Voltaite, deltoidicositetrahedral crystals, Rezi. Scanning electron micrograph.

Lesenceistvánd

Zones, cemented with marcasite occurred in different parts of the gravel open pit, situated near the village. The result of the mineralogical investigations of the adjacent secondary sulphates (copiapite, rhomboclase) were published by KOZÁK *et al.* (1985) and by VICZIÁN *et al.* (1986).

The following sulphates were determined by us on specimens that were collected later, on several occasions: *gypsum, halotrichite, jarosite, melanterite* and *voltaite*. (Halotrichite and melanterite were presumed by KOZÁK *et al.* (1985), too, on the basis of IR-spectra). *Jarosite* forms dust-like tarnish, *gypsum* occurs in acicular aggregates, *melanterite* in greenish spots and incrustations, *halotrichite* in white, fibrous aggregates, *rozenite* in white, curved fibres and *voltaite* occurs in crusts of 0.1–0.3 mm-sized black crystals. Considering, that in the different seasons it was possible to collect different parageneses, the formation of sulphates presumably depends on the humidity of the air and on the temperature.

Felsőpetény

Extremely nice gypsum crystals and aggregates, occurring in large variety and size – partially having secondary origin – were found in the large cavities of the limestone and sandstone layers of the clay mine. They were described by KÁKAY SZABÓ (1992). An interesting sulphate paragenesis was recovered in the end of the 1980's and in the beginning of the 1990's, in the end part of the V. mine opening and in several parts of the adit and also in the left side strike of the V/1 cross adit (HOM 21905). The appearance of these sulphates are not surprising, since disseminated pyrite and/or marcasite occur both in the limestone and in the sandstone. The abundance of these sulphides could be observed in several places, commonly occurring in crystals and aggregates of a few mm size. It is sure that the following secondary sulphates have been formed by the weathering of these sulphides which were detected by the instrumental tests (XRD L138, L139). *Starkeyite* occurs in 3–5 cm long, white, fibrous aggregates, *halotrichite* in 1–3 mm-sized, white bundles. *Melanterite* appears in bottle-green nodules of 2–4 cm size, having glassy lustre and in fissures up to 1 cm thickness, appearing in the clay, which is black because of its iron sulphate content. Fibrous, dull, white *rozenite* aggregates were formed by the weathering of melanterite. *Jarosite* appears rarely in light-yellow, earthy patches in the clay. *Gypsum* and a small amount of *jarosite* occur in the large open pit. White, fibrous aggregates of *halotrichite* can be found on the surface of the marcasite-pyrite concretions, which appear in the clay.

Kecskemét, Úri Hill

Together with chlorides and carbonates, several sulphates species occur in the superficial efflorescences of sodaic areas. Among the sulphates, only the appearance of *thenardite* is certain (XRD G240) at present; it forms white, flour-like disseminations.

4. SECONDARY MINERALS, OCCURRING IN METAMORPHIC ROCKS (IN THE SURROUNDINGS OF DISSEMINATED SULPHIDES)

Jarosite was found in numerous outcrops, in the fissures of the metamorphic rocks of the Sopron Mountains. The conditions of the formation of this jarosite are completely the same as the above listed ones; it is mainly connected to the pyrite zones. Jarosite of the gneiss quarry of Kő Hill in Kópháza is remarkable; it occurs in large amounts together with goethite in the outcrops of the gneiss, close to the surface (KISHÁZI & IVANCSICS, 1977). The ocher-brown, yellow jarosite forms 1–3 mm thick incrustations or dust-like aggregations on the walls of the fissures in the gneiss. It appears the goethite as well, forming olive-green, 0.1–0.2 mm thick crusts. In this jarosite, phosphor was also detected by EDX. The ratio of the sulphur and phosphor is 3:1 by semi-quantitative microprobe analysis. As it can be seen on the SEM images, the olive-green crust consists of 15–35 μm-sized thin-tabular crystals. *Gypsum* occurs in the cracks of the goethite residuum, forming 1–2 mm long, acicular crystals. A nearly 2 cm-sized sulphide nodule was found once in the quartz vein of the gneiss. According to the microprobe and ore microscopic investigations, this nodule consists of stibnite, pyrite, chalcopyrite, galena and marcasite. Goethite and *anglesite* were found as secondary minerals on the border of the sulphides.

A small amount of *gypsum* and *jarosite* were found by us in the fissures of the weathered, – secondary iron oxide-rich – serpentinite, which borders the talk deposit of Felsőcsatár. Malachite and azurite also occur in this mineral assemblage.

1–2 mm long *gypsum* crystals appear in large amounts in the old schist quarry of Kisgyőr, Bükk Mountains, on the cleavage surfaces of the clay schist that contains disseminated pyrite. Gypsum, sometimes together with jarosite, occurs frequently in similar structure; in the other clay schist outcrops of the Bükk Mountains. White and colourless incrustations and botryoidal aggregates of *epsomite* and *pickeringite* (XRD, A69) appear together with yellow, dust-like dissemination of *jarosite* on the clay schist walls of the abandoned Heinrich adit, near Dédestapolcsány.

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REFERENCES

BÁRDOSSY, Gy. (1977): Karsztbauxitok. Akadémiai kiadó, Budapest. 413.

BÁRDOSSY, Gy. & HAJÓS, M. (1963): A szurdokpüspöki diatómás rétegösszletek üledékföldtani és geokémiai jellemzése. MÁFI Évi Jel. 1960-ról. 121—146.

BOKOR, Gy. (1939): A Budai-hegység nyugati peremének földtani viszonyai. Földt. Közl., 69, 219—268.

BRUMMER, E. (1937): A kiscelli fennsík és környékének ásványai II. A Bohn-féle Téglagyár agyaggödre. Földt. Ért., 2. új évf. 172—177.

COCCO, G. (1952): D.T.A. of some sulphates. Period. Miner., 21, 103—141.

CVETKOV, A. I. & VALYASHSCIKHINA, E. N. (1955): Termoanaliticseszküje karakterisztiki szulfatnih mineralov. Akad. Nauk. CCCP. 30—109.

CSONGRÁDI, J. (1984): Hidrotermális kőzetelváltozások a gyöngyössolymosi üstökfői higany-indikációban. Földt. Közl., 114, 113—121.

DUBANSKY, A. in: Mackenzie R. C. Scifax (1962): Differential Thermal Analysis Data Index.

ELSHOLTZ, L., SELMECZINÉ ANTAL, P. & SELMECZI, B. (1969): Másodlagos foszfátásványok az Upponyi-hegység karbon korú palaösszletéből. Kutatási jelentés. Kézirat. MÉV Adattár.

ERDÉLYI, J. & TOLNAI, V. (1954): Jarosite from Mount Gécsi. Acta Miner. Petr., Szeged, 7, 65—67.

ERDÉLYI, J., KOBLENCZ, V. & TOLNAY, V. (1957): A nagybörzsönyi agyagásvány és az ércesedés néhány újabb kísérőásványa. Földt. Közl., 87, 400–418.

FÁBIÁN, T. & GIMESI, I. (1986): Gipszkristályok Szikszóról. Ásv.gyűjtő Figyelő. 3, 43.

FÖLDVÁRI, A. (1929): Adatok a Bia-Tétényi plató oligocén-miocén rétegeinek sztratigráfiájához. Ann. Hist.-nat. Mus. Nat. Hung., 26, 35—59.

FÖLDVÁRI, A. (1942): Jelentés a M. Kir. Földtani Intézet igazgatóságának rendelete értelmében Sima, Erdőbénye és Szegilong között az 1973. évben végzett kaolin kutatásokról. M. Kir. Földt. Int. Évi Jel. az 1936–38. évekről. 1245—1258.

HOFFER, A. (1937): A Szerencsi-sziget földtani viszonyai. Tisia, 2. 307.

HÖLZEL, A.R. (1992): Datenbank der Mineralien (MDAT92). Ulmenring, Ober-Olm

JÁMBOR, Á. (1960): Jarosit kötőanyagú homokkő a Szendrői hegység DK-i peremén. Földt. Közl., 90, 363—368.

JUGOVICS, L. (1915): Ásványtani közlemények. Földt. Közl., 45, 174—178.
KASZANITZKY, F. (1959): A pátkai kőrakáshegyi érckutatás jelenlegi állása. Földt. Közl., 89, 133—142.
KÁKAY SZABÓ, O. (1992): Primer és szekunder gipszkristály óriások Felsőpetényből. MÁFI Évi Jel. az 1990. évről. 277—304.
KISHÁZI, P. & IVANCSICS, J. (1977): XXV/1/77. sz. téma kutatási részjelentés. Litosztratigráfiai alapszelvények nyugat-magyarországi metamorf kőzetsorozatban. Kézirat. MGSZ Adattár.
KISS, J. & JÁNOSI, M. (1993): Mg-minerals of recent hydrothermal formations of the Cu-porphyric mineralization at Recsk, Hungary. Acta Miner. Petr., Szeged, 34, 7—19.
KOCH, A. (1871): A Bakonyhegység északnyugati részének Nummulit képlete és fiatalabb képződményei. Földt. Közl., 1, 118—124.
KOCH, S. (1985): Magyarország ásványai. II. kiadás. (szerk. Mezősi J.). Akadémiai kiadó. Budapest. 562.
KOZÁK, M., SZŐŐR, GY. & FÉLSZERFALVI, J. (1985): Teletermális markazit impregnáció és hozzákapcsolódó szekunder ásványparagenezis az uzsai pleisztocén kavicsösszletben. Acta Geographica Debrecina. 22, 65—73.
KULCSÁR, L. (1976): A Tarpa-Barabás környéki felszíni vulkanitok és a Barabás 1.sz. fúrás anyagvizsgálati eredményeinek értékelése. Kutatási jelentés. Kézirat. MGSZ Adattár.
MAJOROS, Gy. (1960): A badacsonyörsi perm uránelőfordulás ásvány- és kőzettani jellemzése. Kutatási jelentés. Kézirat. MGSZ Adattár.
MAURITZ, B. (1958): Újabb ásványkőzettani érdekességek hazánkban. Földt. Közl., 88, 447—452.
MIKLÓS, G. (1987): Az alsótelekesi gipsz- és anhidritelőfordulás ásvány-kőzettani, földtani-teleptani és hegységszerkezeti vizsgálata. Egyetemi doktori értekezés. Kézirat. Miskolci Egyetem.
NAGY, B. (1979): A Budai-hegységi porlott dolomitok ásvány-kőzettani, geokémiai és genetikai vizsgálata. Földt. Közl., 109, 46—74.
NAGY, B. (1984): A Börzsöny-hegységi hidrotermális ércesedések komplex ércföldtani és geokémiai vizsgálata. Kandidátusi értekezés. Kézirat. MTA Adattár.
NAGY, B. (1985): Arany-, ezüst- és bizmuttelluridok a parádfürdői ércesedés ásványparagenezisében. MÁFI Évi Jel. az 1983. évről. 321—357.
NAGY, B. (1986): A gyöngyösoroszi ércesedés ásványtani felépítése. MÁFI Évi Jel. az 1984. évről. 404—423.
NAGY, B. (1990): Nagyirtáspusztai ércesedés (Börzsöny hegység). MÁFI Évi Jel. az 1988. évről. I. rész. 277—325.
NOSKE-FAZEKAS, G. & NAGY-MELLES, M. (1969): Kőzettan. in. A Mecsek hegység alsóliász kőszénösszlete. MÁFI Évk. 51 (2) 319—407.
PAPP, G. (1990): Szulfát ásványtársulás Tokodról. Földt. Közl., 120, 93—99.
PECHÁCSEK-SERES, E. (1990): Közép-Tiszavidéki agyagbányák gipsz előfordulásainak vizsgálata. Szakdolgozat. Kézirat. JATE. Szeged.
SELMECZI, B-né. (1973): Az Upponyi-hegységi kutatási terület mintáinak anyagvizsgálati dokumentációja. Kutatási jelentés. Kézirat. MÉV Adattár.
SCHAFARZIK, F. (1884): *Jelentés az 1883. év nyarán a Pilishegységben eszközölt földtani részletes felvételről.* M. Kir. Földt. Int. Évi Jel. az 1883. évről. 91—132.
SCHAFARZIK, F. (1913): Ásványtani közlemények. Földt. Közl., 43, 74.
SCHMIDT, S. (1900): A Gellért-hegyi fluorit. Földt. Közl., 30, 173—174.
SZABÓ, J. (1872): Az ajkai kőszéntelep a Bakonyban. Földt. Közl., 2, 124.
SZAKÁLL, S. (1989): A Tokaji-hegységi Hg-Sb indikációk ásványtani és geokémiai vizsgálata. KFH Kutatási jelentés. Kézirat.
SZAKÁLL, S. (1992): Adatok a Mátra és a Karancs hegycsoport ásványainak ismeretéhez. Fol. Hist.-nat. Mus. Matr., 17, 27—46.
SZAKÁLL, S. (1992): Zeolite minerals from intermediate volcanic rocks from Tokaj Mts. Acta Miner. Petr., Szeged, 32, 25—36.
SZAKÁLL, S., BOGNÁR, L. & KOVÁCS, Á. (1994): A telkibányai érces terület szulfátásványai. Topogr. Mineral. Hung., II. 233—247.
SZAKÁLL, S. (1994): A magyarországi középiskolák ásványgyűjteményei. in: Földünk hazai kincsesházai. (szerk. Kecskeméti, T. & Papp, G.). Magyar Természettudományi Múzeum. Budapest. 247—263.
SZAKÁLL, S., BIRCH, W. D., KOVÁCS, Á. & POSTL, W.(1994): Arsenate minerals from Hungary. Acta Miner. Petr., Szeged, 35, 5—27.
SZAKÁLL, S. & FÖLDVÁRI, M. (1994): Foszfátásványok a recski és a parád-parádfürdői ércesedésekből. Folia Hist.-nat. Mus. Matr., 19, 23—36.
SZAKÁLL, S., DÓDONY, I. & KOVÁCS, Á. (1995): Volfrámásványok Nagybörzsönyből. Folia Hist.-nat. Mus. Matr. 20, 3—12.
SZÉKY-FUX, V. (1970): Telkibánya ércesedése és kárpáti kapcsolatai. Akadémiai kiadó. Budapest. 266.

SZONTAGH, T. (1882): Az „Aesculap Bitter Water Company Limited London" cég kelenföldi (budai) kútjairól. Földt. Közl., 12, 99—104.
SZÓNOKY, M. (1987): Gipszkristályok Kisújszállásról. Ásv.gyűjtő Figyelő, 3, 2—7.
TOBORFFY, Z. (1907): Adatok a magyar calcitok és gypsek ismeretéhez. Földt. Közl, 37, 247—252.
TOBORFFY, Z. (1910): A gánti timsós vízű kút ásványai. Földt. Közl., 40, 184—185.
TODOR, D. N. (1972): Analiza termica a mineralilor. Editura Technica. Bucureşti.
TOKODY, L. (1965): Mineralien des Kopaszhegy bei Tállya im Tokajer Gebirge. Ann. Mus. Nat. Hung., 55, 11—21.
VENDL, M. (1922): Calcit Vaskőről, antimonit Hondolról, gipsz Óbudáról és markazit Nemesvitáról. Földt. Közl., 51–52, 39—45.
VICZIÁN, I., KOZÁK, M. & SZŐŐR, Gy. (1986): Markazit, copiapit és romboklász az uzsai alsó-pannóniai kavicsösszletben. MÁFI Évi Jel. az 1984. évről. 378—387.
VINCZE, J. & SELMECZI, B-né. (1976–1980): Tájékoztató kutatási jelentések az Északi-Bükk-hegységi minták komplex anyagvizsgálatában elért eredményekről. Kutatási jelentés. Kézirat. MÉV Adattár.
VITÁLIS, I. (1922): Jelentés a gömörvármegyei Imola község gipsz, vasérc és szénelőfordulásáról. Kézirat. MGSZ Adattár.
WEISZBURG, T. (1981): Jelentés a csordakúti mellitelőfordulás vizsgálatáról. Kézirat.

TABLE 1.

Secondary sulphate parageneses from Hungary
(mineral species written by italics are the new informations)

I. Sulphide ore deposits

VELENCE MTS.
Szabadbattyán (Kiss, 1951)
anglesite, *fornacite, gypsum, jarosite*
Pátka, Kőrakás Hill, Szűzvár Mill (Kaszanitzky, 1959)
gypsum, *jarosite*
Sukoró, Ördög Hill
gypsum, jarosite

BÖRZSÖNY MTS.
Nagybörzsöny (Nagy: in Koch, 1985)
alunogen, *anglesite,* chalcanthite, *copiapite,* epsomite, gypsum, goslarite, jarosite, melanterite, rozenite, *römerite, siderotil, szomolnokite, voltaite*
Márianosztra, Nagyirtáspuszta (Nagy, 1990)
epsomite, gypsum, melanterite, rozenite

CSERHÁT MTS.
Salgótarján, Karancs Hill
gypsum, jarosite

MÁTRA MTS.
Gyöngyösoroszi, Mátraszentimre (Nagy, 1986)
anglesite, goslarite, gypsum, halotrichite, jarosite, melanterite, rozenite, *thenardite*
Gyöngyösoroszi-Károlytáró
anglesite, gypsum, jarosite
Gyöngyössolymos, Névtelen-bérc adit
devilline, gypsum, jarosite
Parádsasvár, Béke adit
devilline, gypsum, jarosite
Parád-Parádfürdő, Hegyes Hill (Nagy, 1985)
gypsum, halotrichite, jarosite, melanterite
Parád-Parádfürdő, Vaskapu adit (Szakáll & Földvári, 1994)
gypsum, jarosite
Parád-Parádfürdő, Orczy adit
gypsum, jarosite
Parád-Parádfürdő, Hosszú-bérc open pit (Szakáll & Földvári, 1994)
gypsum, jarosite
Parád-Parádfürdő, Egyesség adit
coquimbite, gypsum, halotrichite, jarosite
Recsk, Lahóca Hill (Koch, 1985)
brochantite, chalcanthite, copiapite, coquimbite, gypsum, halotrichite, jarosite, kalinite, mendozite, *szomolnokite*
Recsk, –700 m and –900 m level (Kiss & Jánosi, 1993)
blödite, *bonattite,* brochantite, chalcanthite, epsomite, gypsum, *sideronatrite, siderotil,* thenardite

RUDABÁNYA MTS.
Rudabánya (Koch, 1985; Nagy, 1982; Szakáll, 1992)
anglesite, *antlerite,* barite, *botryogen, brochantite,* chalcanthite, *copiapite, devilline,* epsomite, *fibroferrite,* gypsum, halotrichite, hexahydrite, *jarosite, linarite, magnesiocopiapite,* melanterite, *plumbojarosite, posnjakite, rozenite, serpierite, siderotil, slavíkite, starkeyite, szomolnokite*
Martonyi
gypsum, jarosite, posnjakite

TOKAJ MTS.
Telkibánya (Széky-Fux, 1970; Szakáll et al., 1994)
alunogen, anglesite, gypsum, halotrichite, jarosite, melanterite, plumbojarosite

II. Magmatic rocks

BAKONY MTS.
Badacsonytördemic (Mauritz, 1958)
gypsum

VELENCE MTS.
Velence, Gécsi Hill (Erdélyi & Tolnai, 1954)
jarosite

BÖRZSÖNY
Márianosztra, Medres stream, andesite quarry
gypsum

CSERHÁT MTS.
Karancsberény, Homorú Hill, andesite quarry
gypsum, jarosite

MÁTRA MTS.
Recsk, Csákány-kő Hill, andesite quarry
gypsum
Parádsasvár, Rudolftanya, andesite quarry
gypsum, halotrichite, jarosite
Parádsasvár, Nagylápa-fő, andesite quarry
gypsum, jarosite

BÜKK MTS.
Bükkszentlászló, Messzelátó Hill
jarosite

TOKAJ MTS.
Kéked (Koch, 1985, Szakáll et al., 1994)
jarosite, melanterite, rozenite
Tállya (Tokody, 1965)
epsomite, hexahydrite, gypsum, *jarosite, pickeringite*
Regéc, Torintás (Szakáll, 1992)
gypsum, jarosite
Tolcsva, Tér Hill
jarosite
Komlóska, Bolhás Hill
gypsum

GREAT HUNGARIAN PLAIN
Tarpa (Kulcsár, 1976)
gypsum

III. Sedimentary rocks
III.1. Manganese deposits

BAKONY MTS.
Úrkút (Koch, 1985)
bassanite, gypsum, *jarosite*

III.2. Uranium deposits

MECSEK MTS.
Kővágószőlős (Vincze: in Koch, 1985)
gypsum, *jarosite, thenardite,* uranopilite, zippeite

Sámsonháza (Szakáll, 1992)
gypsum

Kisnána, Hátsó-Tarnóca stream, andesite quarry
gypsum, szomolnokite
Gyöngyössolymos, Kis Hill, rhyolite quarry
jarosite

Abaújszántó, Sulyom Hill, Süveges Hill
jarosite
Gönc, Fenyő-kő Hill, rhyolite quarry
jarosite
Rátka, Hercegköves, limnoquartzite quarry
copiapite, rozenite, szomolnokite
Erdőbénye, Erdőbényefürdő (Földvári, 1942)
gypsum, *jarosite*
Telkibánya, Fehér Hill and Király Hill (Szakáll et al., 1994)
jarosite

Eplény (Koch, 1985)
gypsum, *jarosite*

BAKONY MTS.
Badacsonyörs (Majoros, 1960)
gypsum, zippeite

BÜKK MTS.
Nagyvisnyó (Vincze & Selmeczi, 1976–1980)
anglesite, gypsum, jarosite

III. 3. Bauxite deposits

BAKONY, VÉRTES AND GERECSE MTS.
Eplény, Gánt, Iszkaszentgyörgy, Nagyegyháza, Nyirád, Szőc, etc. (Bárdossy: in Koch, 1985)
aluminite, alunite, *alunogen*, anhydrite, barite, basaluminite, bassanite, celestite, gypsum, *jarosite*, melanterite, parabutlerite, rozenite, szomolnokite

III. 4. Phosphate deposits

UPPONY MTS.
Dédestapolcsány, Nekézseny (Elsholtz, Selmeczíné Antal & Selmeczi, 1969)
gypsum, jarosite

III. 5. Coal deposits

SOPRON MTS.
Sopron-Brennbergbánya, Hermes shaft
gypsum, jarosite, rozenite

MECSEK MTS.
Komló (Noske-Fazekas & Nagy-Melles, 1969)
alunogen, gypsum, halotrichite, jarosite, melanterite, rozenite, szomolnokite
Pécs (Noske-Fazekas & Nagy-Melles,1969)
gypsum, jarosite, melanterite, rozenite, szomolnokite
Hidas (Noske-Fazekas & Nagy-Melles, 1969)
gypsum, jarosite, melanterite, rozenite

BAKONY MTS.
Ajka (Szabó, 1872)
gypsum, *jarosite*
Herend
gypsum
Dudar
gypsum, jarosite
Várpalota, Inota-puszta
anhydrite, gypsum, jarosite, mascagnite, rozenite

GERECSE MTS.
Tatabánya (Koch, 1985)
alunite, epsomite, gypsum, *halotrichite, jarosite, melanterite, rozenite*
Bicske, Csordakút (Weiszburg, 1981)
aluminite, gypsum
Csolnok, Borókás
gypsum
Tokod (Koch, 1985; Papp, 1990)
alunogen, gypsum, epsomite, halotrichite, hydronium jarosite, melanterite, natrojarosite, tschermigite
Mogyorósbánya, open pit
aluminite, gypsum, jarosite, rozenite, tschermigite
Bajna, Hantos-puszta, open pit
aluminite, gypsum, jarosite, rozenite

VÉRTES MTS.
Pusztavám, coal mine
gypsum, jarosite

VISEGRÁD MTS.
Esztergom, Lencse Hill, coal mine
gypsum, jarosite, mascagnite, melanterite, rozenite

BÖRZSÖNY MTS.
Verőce, Katalin Valley
gypsum, jarosite

CSERHÁT MTS.
Kosd (Jugovics, 1915)
gypsum, *jarosite*
Bátonyterenye, Szoros stream shaft (Szakáll, 1992)
gypsum, jarosite, *sodium alum*, thenardite
Bátonyterenye, Kányáspuszta shaft (Szakáll, 1992)
gypsum, jarosite

MÁTRA MTS.
Visonta, lignite open pits
gypsum, jarosite

BÜKK MTS.
Bükkábrány, lignite open pits
gypsum, jarosite
Edelény, Edelény shaft
gypsum, jarosite
Egercsehi
alunogen, copiapite, gypsum, halotrichite, jarosite, rozenite, tamarugite
Ormosbánya, Ormos shaft
barite, gypsum, halotrichite, hexahydrite, letovicite, mascagnite
Izsófalva, open pit
gypsum, jarosite
Királd
gypsum
Kurityán, Fekete Valley shaft
gypsum, hexahydrite, jarosite
Miskolc-Lyukóbánya, Lyukó shaft
alunogen, anhydrite, gypsum, halotrichite, hexahydrite, jarosite, koktaite, mascagnite, millosevichite, rozenite, voltaite
Múcsony, Szeles shaft
gypsum, halotrichite, jarosite, mascagnite
Putnok, Putnok shaft
alunogen, gypsum, hexahydrite, jarosite
Radostyán, open pit
gypsum, hexahydrite, jarosite, pickeringite, starkeyite
Radostyán, old dumps
gypsum, rozenite
Szarvaskő, Keselyű-bérc shaft
gypsum, jarosite, starkeyite

III. 6. Clays (gypsum)
Sopron, Arany Hill, clay mine
Vasvár
Balatonszentgyörgy, clay mine
Szántód, clay mine
Szólád
Nemesvita (Koch, 1985)
Noszlop (Koch, 1871)
Csákvár
Gánt (Toborffy, 1910)
Nagyigmánd (Toborffy, 1907).
Törökbálint
Solymár
Budakalász
Zsámbék
Budapest-Kelenföld (Szontagh, 1882)
Budapest, Bohn clay mine (Brummer, 1937)
Budapest, United Brick Factory, clay mine (Brummer, 1937)
Budapest, Péter Hill (Schafarzik,1913)
Pilisszentkereszt (Schafarzik, 1884)
Lábatlan
Érd (Földvári, 1929)
Páty (Bokor, 1939)
Nógrádmarcal, Magosmáj
Bercel
Kompolt
Szurdokpüspöki (Bárdossy & Hajós, 1963)
Eger, Wind clay mine
Sajóvelezd
Alsótelekes, gypsum open pit (Miklós, 1987)
Alsódobsza (Hoffer,1956)
Szikszó (Fábián & Gimesi, 1937)
Imola (Vitális, 1922)

Szarvas (Szakáll, 1994)
Mezőtúr (Pechácsek-Seres, 1990)
Dévaványa (Pechácsek-Seres, 1990)

Kisújszállás (Szónoky, 1990)
Szeged (Koch, 1985)

III. 7. Other sedimentary rocks

BAKONY MTS.
Rezi, Kotyor stream
gypsum, jarosite, halotrichite, melanterite, rozenite, voltaite

Lesenceistvánd (Kozák et al., 1985; Viczián et al., 1986)
copiapite, gypsum, halotrichite, *jarosite, melanterite,* rhomboclase, *rozenite, voltaite*

BUDA MTS.
Budapest, Mátyás Hill (Koch, 1985)
gypsum
Budapest, Kis-Sváb Hill (Koch, 1985)
gypsum

Budapest, Tündér Hill (Nagy, 1979)
epsomite, gypsum, hexahydrite
Budapest, Gellért Hill (Schmidt, 1900)
gypsum

CSERHÁT MTS.
Vác, Naszály Hill
gypsum
Felsőpetény (Kákay-Szabó, 1992)
gypsum, *halotrichite, jarosite, melanterite, rozenite, starkeyite*

Keszeg (Szakáll, 1992)
gypsum, halotrichite, rozenite
Bátonyterenye (Mauritz, 1958)
gypsum, melanterite

BÜKK MTS.
Miskolc-Diósgyőr, Mexikó Valley, limestone quarry
melanterite, rozenite

CSEREHÁT MTS.
Gadna, Irota (Jámbor, 1960)
jarosite

GREAT HUNGARIAN PLAIN
Kecskemét, Úri Hill
thenardite

IV. Metamorphic rocks

SOPRON MTS.
Kópháza, Kő Hill, quarry (Kisházi & Ivancsics, 1977)
anglesite, gypsum, jarosite
Sopron, Gloriette, quarry
jarosite

Sopron, Vöröshíd
jarosite
Fertőrákos, Gödölye-bérc
jarosite

KŐSZEG MTS.
Felsőcsatár, talc mine
gypsum, jarosite

MECSEK MTS.
Helesfa
gypsum

BÜKK AND UPPONY MTS.
Kisgyőr, quarry
gypsum

Dédestapolcsány, Heinrich adit
epsomite, gypsum, jarosite, pickeringite

TABLE 2.

X-ray powder diffraction data of fornacite from Szabadbattyán

Fornacite, Szabadbattyán		Fornacite, JCPDS 15-200	
d (Å)	I	d (Å)	I
8.23	vw	8.22	50
4.81	s	4.80	90
4.49	vw	4.48	30
4.12	mw	4.12	30
4.03	w	4.00	50
		3.92	30
3.71	m	3.71	50
3.41	vw	3.45	30
		3.38	50
3.32	vs	3.31	100
3.17	mw	3.18	50
3.02	m	3.06	30
2.979	m	2.98	100
2.922	m	2.88	100
2.805	ms	2.80	100
		2.74	30
2.722	ms	2.71	90
2.614	w*	2.62	30
		2.58	30
2.532	w	2.51	30
		2.46	50
		2.43	50
		2.40	50
2.332	m	2.32	30
		2.29	50
		2.24	50
		2.16	30
2.092	mw	2.08	30
2.060	w	2.05	50
2.006	w	2.00	50

Dept. of Geology, University of Modena.

Symbols: vs=very strong, s=strong, m=medium, mw=medium weak, w=weak, vw=very weak, *=broad

TABLE 3.

X-ray powder diffraction data of siderotil from Nagybörzsöny

Siderotil, Nagybörzsöny		Siderotil, JCPDS 22-357	
d (Å)	I	d (Å)	I
		10.5	5
5.72	30	5.73	50
5.56	35	5.57	60
5.06	15	5.07	20
4.88	100	4.89	100
4.56	2	4.57	10
4.35	4	4.35	10
4.04	2	4.04	5
3.89	20	3.90	30
3.69	40	3.73	80
3.43	80	3.44	20
3.27	30	3.29	10
3.20	30	3.21	40
3.08	35	3.07	20
2.93	30	2.92	40
2.86	15	2.86	20
2.77	15	2.76	20
2.71	20	2.72	30
2.66	35	2.68	40
		2.61	5
2.56	20	2.57	10
2.51	30	2.52	5
		2.49	5
2.42	10	2.44	30

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TABLE 4.

X-ray powder diffraction data of antlerite from Rudabánya

Antlerite, Rudabánya		Antlerite, JCPDS 7-407	
d (Å)	I	d (Å)	I
6.81	7	6.8	12
6.02	21	6.01	25
5.42	31	5.40	25
4.86	66	4.86	100
		4.52	10
4.13	7	4.13	8
3.78	14	3.79	16
3.60	52	3.60	75
3.40	24	3.40	10
3.34	34	3.34	10
3.10	21	3.09	16
2.99	14	3.00	18
		2.762	12
		2.698	10
2.688	69	2.683	75
2.570	100	2.566	85

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TABLE 5

X-ray powder diffraction data of linarite from Rudabánya.

Linarite, Rudabánya		Linarite, JCPDS 4-598		Other minerals
d (Å)	I	d (Å)	I	
4.84	7	4.82	20	
4.51	12	4.48	40	
4.25	3			Q
3.62	7			?
3.55	60	3.53	70	S
3.34	15			Q
3.15	25	3.12	100	
3.10	10			?
2.97	6	2.94	20	
2.82	4	2.81	10	
2.75	100			S
2.70	5	2.68	10	
2.58	8			?
2.57	3	2.56	30	
2.45	3			Q
2.39	3	2.39	10	
2.33	25	2.30	30	S
2.26	6	2.24	30	Q
2.18	7			?
2.16	6	2.16	40	
2.11	21	2.09	40	Q,S
2.02	4			?
2.01	6			?
1.949	31			S
1.831	5			?
1.814	6			?
1.795	5	1.79	60b	
1.778	14	1.76	10	S
1.708	38	1.68	20	S

ALUTERV-FKI, Budapest. Symbols: S=smithsonite, Q=quartz.

TABLE 6.

X-ray powder diffraction data of posnjakite from Rudabánya

Posnjakite, Rudabánya		Posnjakite, JCPDS 20-364		Other minerals
d (Å)	I	d (Å)	I	
6.95	35	6.94	100	
6.14	8			?
5.91	8			?
5.42	24			?
		5.25	8	
		5.15	4	
5.00	3	4.85	6	
		4.77	4	
4.26	22			Q
4.18	23			G
3.59	8	3.74	2	
3.52	8			?
3.45	5	3.47	30	
3.34	100	3.33	6	Q
3.13	38	3.23	4	P
3.05	17			?
		2.88	2	
		2.79	2	
2.71	97	2.70	25	P
2.58	5	2.61	16	
2.49	2			G
2.46	26			Q
2.42	44	2.42	25	P
2.39	8			Q
2.34	28	2.33	12	
2.28	15			Q
2.24	3	2.26	8	
2.21	43			P,Q
2.13	5			Q
2.02	46	2.01	12	
1.980	5			Q
1.963	5	1.952	6	
1.913	47			P
1.901	14	1.870	4	
1.814	12			Q
1.757	4			G
1.720	8	1.734	2	
1.690	4			G
1.671	4	1.662	4	
1.633	48	1.616	2	P
1.541	10	1.541	10	

Dept. of Mineralogy, Eötvös L. University, Budapest.
Symbols: G=goethite, Q=quartz, P=pyrite.

TABLE 7.

X-ray powder diffraction data of serpierite from Rudabánya

Serpierite, Rudabánya		Serpierite, JCPDS 22-0148		Devilline, JCPDS 22-231		Other minerals
d (Å)	I	d (Å)	I	d (Å)	I	
10.19	70	10.20	100	10.22	100	
		5.61	10	5.89	10	
5.09	54	5.09	80	5.08	95	
4.75	19	4.74	40	4.67	40	
		4.37	10	4.40	10	
		3.90	10	3.92	5	
3.69	24	3.53	20	3.73	40	+?
3.39	48	3.39	80	3.38	80	
		3.17	40	3.17	40	
2.94	100	3.01	10	3.01	5	+Ten
		2.83	10	2.87	5	
		2.70	60	2.78	20	
		2.65	60	2.65	60	
2.54	21	2.55	40	2.50	60	+Ten
2.39	18	2.44	60	2.38	40	+Ten
		2.29	20	2.25	40	
		2.23	5	2.21	20	
2.16	16	2.17	60	2.16	5	

Dept. of Mineralogy, Steiermärkisches Landesmuseum Joanneum, Graz. Symbols: Ten=tennantite.

TABLE 8.

X-ray powder diffraction data of sodium alum from Bátonyterenye

Sodium alum, Bátonyterenye		Sodium alum, JCPDS 1-397		Other minerals
d (Å)	I	d (Å)	I	
7.62	18			G
4.24	100	4.23	100	
3.96	31	3.98	40	
3.76	10			G
3.66	47	3.65	50	
3.34	26			Q
3.17	10	3.15	8	
3.07	18			G
3.04	7	3.05	6	
2.91	25	2.90	6	
2.82	4			G
2.78	7			G
2.71	11	2.72	12	
2.60	7	2.60	2	
2.46	13	2.47	8	Q
2.33	5	2.32	6	
2.28	9			Q
2.23	4			Q
2.19	9	2.19	4	
2.12	4			Q
2.08	3			G
2.03	4	2.04	2	
1.908	5	1.90	4	
1.882	4			G
1.819	7			Q,G
1.763	4	1.75	2	
1.703	6	1.69	2	

Dept. of Mineralogy, Eötvös L. University, Budapest.
Symbols: G=goethite, Q=quartz.

TABLE 9.

X-ray powder diffraction data of letovicite, mascagnite and sal ammoniac from Ormosbánya

Letovicite, Ormosbánya		Letovicite, JCPDS 21-25		Other minerals
d (Å)	I	d (Å)	I	
5.50	10	5.47	12	
		4.98	85	
4.94	50	4.95	100	
4.62	15	4.65	35	
4.33				M
3.86				S
		3.81	25	
3.76	100	3.77	80	
3.38	75	3.39	75	
3.35	50	3.36	45	
3.12				M
3.04				M
2.93	30	2.93	50	
2.73				S
		2.71	14	
2.516	15	2.518	25	
2.473	10	2.479	16	
2.317				M
2.231	?	2.232	18	S

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Symbols: S=sal ammoniac, M=mascagnite.

TABLE 10.

X-ray powder diffraction data of voltaite from Rezi

Voltaite, Rezi		Voltaite, JCPDS 17-539	
d (Å)	I	d (Å)	I
9.66	ms	9.66	30
7.79	m	7.92	10
		7.52	10
6.73	m	6.79	30
		6.15	20
5.57	s	5.57	70
4.83	w	4.30	10
4.12	m	4.11	10
		3.91	20
3.75	vw	3.77	20
3.64	w	3.63	20
3.548	vs	3.54	100
		3.46	10
3.41	vs	3.41	90
		3.35	10
3.261	mw	3.21	20
3.159	mw	3.15	30
3.053	m	3.04	50
		2.99	10
		2.93	10
2.867	ms	2.86	30
2.801	vw	2.78	10
2.714	vw		
2.637	mw	2.63	20

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Symbols: vs=very strong, s=strong, m=medium, mw=medium weak, w=weak, vw=very weak, *=broad.

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ON THE MINERAL SPECIES FIRST DESCRIBED FROM THE CARPATHIAN REGION

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ABSTRACT

A historical study on the mineral species first described from the Carpathian region is written by the author. Main stages of the research history (first description, major changes in the status of the species, discreditation etc.) are reviewed on the basis of original publications. This paper is an extended and modified version of the preface to that study. After a brief survey of the previous works (regional and international) the geographical and mineralogical scope of this research is discussed. The most important problems of the topic are demonstrated with the examples of several mineral species. A list of valid mineral species first described from the Carpathian region is also given together with some statistical considerations based on this list.

INTRODUCTION

The Commission on Museums of the International Mineralogical Association (IMA CM) launched a project in 1978 to compile all mineral type specimens in an international catalogue (Catalogue of Type Mineral Specimens, CTMS). The project was run by H. J. RÖSLER (Freiberg), later by H. A. STALDER (Bern). The search for type specimens raised the need for a systematic review of the mineral species first described from a given country. As a result of this international activity several papers related to this topic have been published recently (STALDER et al., 1994; DELIENS & STALDER, 1995; PETERSEN, 1996; RAADE, 1996; STALDER et al., 1996). These kinds of studies fill a certain gap in the mineralogical literature, i. e. the lack of a comprehensive data collection on the discovery and research history of the mineral species. HINTZE'S Handbuch der Mineralogie was probably the last significant mineralogical textbook that gave detailed information on the history and synonymy of all known mineral species. The historical part of later reference works is usually not more than the bibliographical data of the original papers describing or redefining a given species.

The collection of data of the CTMS is organised by countries, since the members of the IMA are the mineralogical associations of each country. Nevertheless papers on the history of mineral species are not always confined to present-day political boundaries. The list of mineral species first described from the former Soviet Union is compiled by Russian scientists (see STALDER et al., 1996), however, the type localities of about one-fourth of the reviewed species is outside of Russia.

[1] H-1431 Budapest, Pf.: 137

One has to face similar situation in the Carpathian region. The type localities of about three-fourth of the mineral species first described form here belonged to Hungary at the time of description. This ratio is even higher when the invalid names (species) are concerned. This heritage of the history, the fairly good availability of early mineralogical papers in Hungary and the personal interest made possible to create a comprehensive review on the history of the minerals first described from this geographical-geological unit.

PREVIOUS PAPERS ON THIS FIELD

KOCH (1926) wrote possibly the first, very short paper on the minerals first described from the territory of former (historical) Hungary. A more detailed review was published by ENZSEL & GAZDA (1978), a list of valid species was given by SZAKÁLL & GATTER (1993). Comprehensive reviews on (or lists of) the minerals first described from the present-day territory of Romania were published by MUREŞAN et al. (1990), UDUBAŞA et al. (1992), and NICOLESCU (1996). These papers have usually been written in local languages and even the most comprehensive ones are more or less incomplete both in geographical and mineralogical respect. Some of their data are inaccurate because reference books were frequently used as sources instead of original papers.

THE GEOGRAPHICAL AND MINERALOGICAL SCOPE OF THIS RESEARCH

The Carpathian area in geographical and geological sense traditionally comprise the Carpathian mountain arc stretching from the Danube near Bratislava till the Iron Gate again at the Danube, the mountains and Neogene basins on the inner, and the flysh and molasse zones on the outer side of the arc. The delimitation of the Carpathian area from the adjacent areas of the Alpian system (the Alps, Dinarides and Balkanides) show differences according to the different authors, but practically none of the important mineral localities is affected in this respect. E part of Austria, SE part of the Czech Republic and Poland, the entire Slovakia and Hungary, SW part of the Ukraine, most of the territory of Romania and NE parts of the former Yugoslavia lie within the Carpathian area. The research covered all valid and invalid names first used for a mineral found in the discussed area (except for a few very old terms used in the 18th century). Our aim was to review the history (first description, major changes in the status of the species, discreditation etc.) of these minerals. The initial data set of our research was collected from the well-known reference works of DANA (1892), HINTZE (1897–1968), EMBREY & FULLER (1980) and CLARK (1993), some of the papers quoted above was also used. During the research we made every effort to reach back to the original publications, especially those containing the first description of a mineral. This study is purely historical in character, however, data regarding the status of a few species were taken from other unpublished experimental studies of the author.

EXPERIENCES WITH INTERNATIONAL REFERENCE WORKS

The ultimate aim of our work is to provide detailed information on the research history of the minerals first described from the Carpathian region, as mentioned above. However, in most cases one has to begin with the amendment of the basic data published in international reference books.

Two kinds of frequent errors are found in these books. In the first case the type locality (hereafter abbreviated as TL) itself is wrong: e.g. NICKEL & NICHOLS (1991) gives Alabanda, Caria, Turkey as TL of alabandite and Oruro, Bolivia as TL of andorite, whereas the true TLs are Săcărâmb (former Nagyág), Transylvania, Romania and Baia Sprie (former Felsőbánya), Romania, respectively.

In the other case, which is by far the most frequent, the problems stem from the name of the TL. It is usually derived from a previous reference work or from the original description of the mineral. Because of the drastic territorial changes these names are frequently obsolete ones, so the identification of the actual name and its localisation may cause problems. We show only one example to this type of errors; in this case the same TL (Nagybörzsöny [former Deutschpilsen], Börzsöny Mts., Hungary) is misnamed and/or misplaced in different countries:

– „Plseň (Pilsen), Czechoslovakia" (p. 166 in NICKEL & NICHOLS, 1991)
– „Deutsch-Pilsen, Germany" (p. 85 in CLARK, 1993)
– „Deutsch-Pilsen (=Borszony), Hungary" (p. 747 in CLARK, 1993)

TYPE LOCALITY AND FIRST DESCRIPTION OF A SPECIES – CASE STUDIES

For the discussion of the history of the minerals first described from the Carpathian region, first we have to answer the apparently simple question: which is the first description of a given species? It is a frequent problem in the case of „old" minerals, i.e. those species that had already been known before they got their recently used name. To diminish the role of subjectivity, the appropriate parts of DANA's (1892) rules on priority (Introduction, IV. Nomenclature, 13. Limitations of the Law of Priority, points c., d., and f.) have been applied in these cases. Accordingly, one can regard the earliest account on the mineral as the first description of a valid species is, unless

1. „a name is put forth without a description";
2. „the description is so incorrect that a recognition of the mineral by means of it is impossible (...)";
3. „a name has been lost sight of and has found no one to assert its claim for a period of more than fifty years; especially if the later name adopted for the species has become intimately incorporated with structure of the science or with the nomenclature of rocks."

The examples of different cases are as follows:

Case 1. Both the oldest description and the recently used name refer to a mineral from the Carpathian region: 1.1. nagyágite, 1.2. tellurite.

Case 2. The oldest description is from the Carpathian region, but the recently used name was originally applied to a mineral from another locality: 2.1. alabandite, 2.2. rhodonite, 2.3. bournonite, 2.4. tremolite.

Case 3. The recently used name was originally applied to a mineral from a locality in the Carpathian region, however, the mineral was first mentioned from another (or unknown) locality: 3.1. rhodochrosite, 3.2. hemimorphite (special case).

Case 4. Simultaneous description from two localities: 4.1. krautite, 4.2. kotoite.

Case 5. First description from a meteorite that fell or was found in the Carpathian region: 5.1. cohenite.

Case 6. First description from an unknown or uncertain locality of the Carpathian region: 6.1. whewellite, 6.2. hörnesite.

Detailed reviews of the history of the discussed species will be given by Papp (in prep.).

Case 1. Both the oldest description and the recently used name refer to a mineral from the Carpathian region.

Example 1: nagyágite

Latest TL data: „Săcărâmb (Nagyág), Transylvania, Romania" (NICKEL & NICHOLS, 1991), „Nagyag, Transylvania, Romania" (CLARK, 1993)

HAIDINGER (1845)* is mentioned as the author of nagyágite in handbooks that have no lists of synonyms, like that of STRUNZ (1982) or NICKEL & NICHOLS (1991). Actually HAIDINGER only introduced the recently used name (without any further investigation of the mineral). In other manuals like that of PALACHE et al. (1944) or HINTZE (1904) one can find SCOPOLI and BORN (1772) as first describers of this mineral and the term *Aurum Galena, Ferro, et particulis volatilibus mineralisatum* as the oldest denomination of the mineral. The very first author, who published analytical data on the later nagyágite was really SCOPOLI (1769) who named it *Minera aurifera Nagyayense [sic].* The very first – though rather vague – reference to the mineral, however, is a little bit earlier. FRIDVALSZKY (1767) wrote in his Transylvanian Mineralogy that „at Nagyág a miraculous sort of mineral is found, which resembles the pure or slightly argentiferous antimony, but it is much heavier and having placed in fire, following the volatilisation of the antimony, gives some silver and a great amount of gold".

One can debate whether FRIDVALSZKY or SCOPOLI is the discoverer of nagyágite, but the TL is undoubtedly Nagyág (now Săcărâmb in Transylvania, Romania), whoever the first describer was.

Example 2: tellurite

Latest TL data: none (Nickel & Nichols, 1991), „Sibenburgen, Transylvania, Romania" (CLARK, 1993)

NICOL (1849) is given as the author of tellurite by STRUNZ (1982) or NICKEL & NICHOLS (1991). As a matter of fact this term was used first by HAIDINGER (1845) for the mineral described by PETZ (1842) without locality data (but obviously from the present Fața Băii, cf. HAIDINGER, 1845) as *„tellurige Säure"* (cf. CLARK, 1993). Tellurite formed finely striated, yellowish white spherules. Long before this paper STÜTZ (1803) already observed very small, wax-yellow, glassy, translucent, radiating nodules in tellurium ore from Sigismundi Mine at „Faczebaia". He supposed the mineral to be a „sparry tellurium". However, the oldest data to the mineral is published by ESMARK (1798), who found in the

* For brevity the bibliographical data of the original papers quoted among the examples are omitted.

same mine yellowish grey, translucent, elongated, six-sided platelets with adamantine lustre. Tellurium being unknown that time he considered it to be antimony ocher.

Again the TL is Facebánya near Zalatna (now Fața Baii near Zlatna), in Transylvania, Romania, whoever the first describer was.

Case 2. The oldest description is from the Carpathian region, but the recently used name was originally applied to a mineral from another locality.

Example 1: alabandite

Latest TL data: „Alabanda, Caria, Turkey" (NICKEL & NICHOLS, 1991), „Nagyag, (Transylvania), Romania" (CLARK, 1993)

The first identifiable description (MÜLLER, 1784) of the later alabandite, including simple physical and chemical tests, was based on specimens from Nagyág. MÜLLER named the mineral *schwarze Blende.* Further chemical studies on Nagyág samples were published by BINDHEIM (1784), KLAPROTH (1802) and PROUST (1802). In 1804 DEL RIO described the mineral from Mexico (parish of Quezaltepeque) as *alabandina sulfúrea.* This later name was transformed to alabandine by BEUDANT (1832) who cited analytical data on specimens from Nagyág and gave the localities as follows: Nagyág, Mexico, Cornwall.

In this case the TL must be Nagyág (now Săcărâmb, Transylvania, Romania) according to the principle of priority.

Example 2: rhodonite

Latest TL data: none (NICKEL & NICHOLS, 1991; Clark, 1993)

The first quantitative analysis of the mineral was published by RUPRECHT (1783). He analysed the „reddish gangue or so-called feldspar" from Kapnikbánya (now Cavnic in Romania) known also as *Kapniker Feldspath* (feldspar from Kapnik). He regarded the mineral as a quartz (or jasper) „penetrated" with manganese, however, others, like KARSTEN (1800) regarded it as distinct species. There was a lot of confusion between rhodonite and rhodochrosite (see below). The term rhodonite was first used by JASCHE (1819) to a mineral from Elbingerode (Harz Mts., Germany).

TL should be Kapnikbánya (now Cavnic in Romania) according to the principle of priority.

Example 3: bournonite

Latest TL data: „Wheal Boys, Endellion, Cornwall, England" (NICKEL & NICHOLS, 1991); „Huel (=Wheal) Boys, Endellion, Cornwall, England" (CLARK, 1993)

Bournonite is generally known to has been described and depicted first as „ore of antimony" by RASHLEIGH (1797) from Cornwall; its recent name was given by JAMESON (1805).

Nevertheless this mineral was described a few years before from Kapnikbánya (now Cavnic in Romania) as well. FICHTEL (1791) mentioned a variety of *Weisgülden* (silver-containing fahlore) from „Kapnik" forming small, short, lengthways striated cylinders of plate-like discs with cut or striated rim. Earlier FERBER (1789) also described a *Weissgülden* specimen from „Kapnick" as prisms that are striated on their opposite sides, like the cog-wheels of a cylindrical pocket-watch.

Although ESMARK (1798) citing FICHTEL also supplied a detailed morphological description of this „curiously crystallized" *Fahlerz,* the contemporary scientists obviously

overlooked these early observations, thus one cannot regard Kapnik as the TL of bournonite.

Example 4: tremolite

Latest TL data: „Tremola valley, St. Gotthard, Switzerland" (NICKEL & NICHOLS, 1991), „Val Tremola, St. Gotthard, Switzerland" (CLARK, 1993)

According to the available reference works tremolite was named by PINI in DE SAUSSURE (1796) after Val Tremola in Switzerland, however, 5 years before FICHTEL (1791) already raised objections against this name in a footnote of his book proposing the term schebeschit(e) instead. Schebeschite corresponds to his earlier *Säulenspath* or *Sternspath* (FICHTEL, 1782) that he found at „Unter-Schebesch" (Oltalsósebes, now Sebeşu de Jos in Romania). The detailed description of these varieties was published together with two chemical analyses of BINDHEIM. These observations were quickly forgotten, and DANA (1892), HINTZE (1897), CLARK (1993), etc. mention only sebesite of BREITHAUPT (1847) what refers to the same mineral from the same locality. Curiously enough, Val Tremola is also questionable as real TL, because, according to HINTZE (1897), tremolite is not found in Tremola valley itself but in the Campolungo area some 20 km SE from there.

Case 3. The recently used name was (or thought to have been) originally applied to a mineral from a locality in the Carpathian region, however, the mineral was first mentioned from another (or unknown) locality.

Example 1: rhodochrosite

Latest TL data: none (NICKEL & NICHOLS, 1991), „Kapnik, Siebenbürgen, Transylvania, Romania" (CLARK, 1993)

The first reference to this mineral is usually attributed to BERGMAN (1782), who used the term *Magnesium acido aereo mineralisatum* without any description or locality data (see e.g. DANA, 1892; or HINTZE, 1927). It is to be noted, however, that BERGMAN (1780) already described *magnesium aëratum* as the matrix of *minera Nagyayensis* (nagyágite). Rhodochrosite from Nagyág (now Săcărâmb in Romania) was described later in details by FICHTEL (1794). His and others' observations were published together with RUPRECHT's analytical data of rhodonite (see above) by LENZ (1794). This confusion between manganese silicate and carbonate lasted for decades. The new term rhodochrosite was introduced by HAUSMANN (1813) referring to the results of the first correct quantitative analysis made by LAMPADIUS (1800) on a specimen from Kapnik (now Cavnic in Romania).

TL should be Nagyág (now Săcărâmb in Romania) according to the principle of prioity.

Example 2: hemimorphite

Latest TL data: none (NICKEL & NICHOLS, 1991), „Rezbanya, Hungary" (CLARK, 1993)

The confusion with zinc silicate and carbonate was as complete as with manganese silicate and carbonate for a long time. The ambiguity began in the antiquity: *Cadmia* of Pliny corresponds to hemimorphite and smithsonite as well (and also to ZnO). The first rough quantitative chemical analysis of the two kinds of native calamine was published by BERGMAN (1780). The silicate he examined was a *lapis calaminaris hungaricus,* i.e. a

specimen from Hungary (without closer locality data). The first accurate comparative chemical analysis of the later hemimorphite and smithsonite was published by SMITHSON (1803). The electric calamine (i.e. hemimorphite) he studied had come from Rézbánya, Hungary (now Băiţa [Bihor] in Romania). Hemimorphite name was introduced only in 1853 by KENNGOTT without further studies and without referring to a locality.

In this case the TL is not determinable.

Case 4. Simultaneous description from two localities

Example 1: krautite

Latest TL data: „Cavnic, Crisana-Maramures, Romania" (NICKEL & NICHOLS, 1991), „Nagyag (Sacaramb) and Kapnik (Cavnic), Transylvania, Romania" (CLARK, 1993)

Krautite was described by FONTAN et al. (1975) using specimens both from Săcărâmb (former Nagyág) and Cavnic (former Kapnikbánya), however, only Săcărâmb was designated as TL („type deposit") by the authors.

Example 2: kotoite

Latest TL data: „Hol Kol Gold Mine, Wall Rock of „New Ore Body", Suan, Korea" (NICKEL & NICHOLS, 1991), „Hol Kol mine, Suan Co., Korea" (CLARK, 1993)

The new mineral was first found by Watanabe in specimens from Hol Kol gold mine near Suan, Korea (now in PRK). At the same time he recognised it in a szaibelyite-containing marble from Rézbánya (Băiţa [Bihor] in Romania) as well. Results of investigation of kotoite from both localities were reported together. TL was not designated explicitly by Watanabe, but he obviously regarded Hol Kol as TL (see especially author's abstract in Fortschr. Min. Krist. Petr., vol. 23, cxlvi–cxlvii).

Case 5. First description from a meteorite that fell or was found in the Carpathian region

Example: cohenite

Latest TL data: „Uivfaq, Disko, Greenland" (NICKEL & NICHOLS, 1991), „first observed in the Arva iron" (CLARK, 1993)

Cohenite was described by WEINSCHENK (1889) from the so-called Arva or Magura meteorite that had been found in 1840 near Szlanica in the Árvai-Magura Mts. (now Slanická Osada in Oravská Magura Mts., Slovakia).

Case 6. First description from an unknown or uncertain locality of the Carpathian region

Example 1: whewellite

Latest TL data: „Havre (near), Montana, USA" (NICKEL & NICHOLS, 1991), „unknown" (CLARK, 1993)

Whewellite was described by BROOKE (1840) from a specimen that was supposed to had been found in Hungary. Accepting this supposition the most probable locality of the mineral is Cavnic (former Kapnikbánya) where several big whewellite crystals were found in this century.

Example 2: hörnesite

Latest TL data: „Oravița (Oravicza), Banat, Romania" (NICKEL & NICHOLS, 1991), „Banat, Hungary" (CLARK, 1993)

Hörnesite was described by HAIDINGER (1859, 1860) and KENNGOTT (1860) from a museum specimen that had earlier been purchased from the collection of VON NÜLL (or NULL). According to the catalogue of this collection (MOHS, 1804) the specimen came from an unspecified mine in the Banat. KENNGOTT (in HAIDINGER, 1860) supposed „Oravitza" (now Oravița in Romania) as locality on the basis of the garnet crystals grown in the accompanying calcite. One has to remark, however, that this paragenesis in not uncommon in other localities of the Banat as well.

STATISTICAL CONSIDERATIONS

The number of the species (more than 50, Table 1) allows us to make some statistical considerations.

Regarding the distribution of species among mineral classes (Fig. 1), the predominance of elements (incl. some meteoritic minerals) and sulphides and their alteration products (sulphates and phosphates, incl. arsenates) is striking. This fact evidently corresponds to the character of the most important ore occurrences mined in the last centuries, i.e. hydrothermal vein- or stockwork-type deposits with non-ferrous metals and gold; the importance of skarn-related deposits is demonstrated by two borate species but these mines of course supplied new minerals belonging to other classes as well. The most „productive" localities of new species are Săcărâmb (former Nagyág), 7; Baia Sprie (former Felsőbánya), 6; Băița [Bihor] (former Rézbánya), 4; L'ubietová (former Libetbánya/Libethen) and Smolník (former Szomolnok/Schmöllnitz), 3 new species.

The greatest number of new species from the Carpathian area was described by J. KRENNER (8). W. HAIDINGER is the most prominent „godfather"; he described two new species from the area, but renamed five earlier discovered ones.

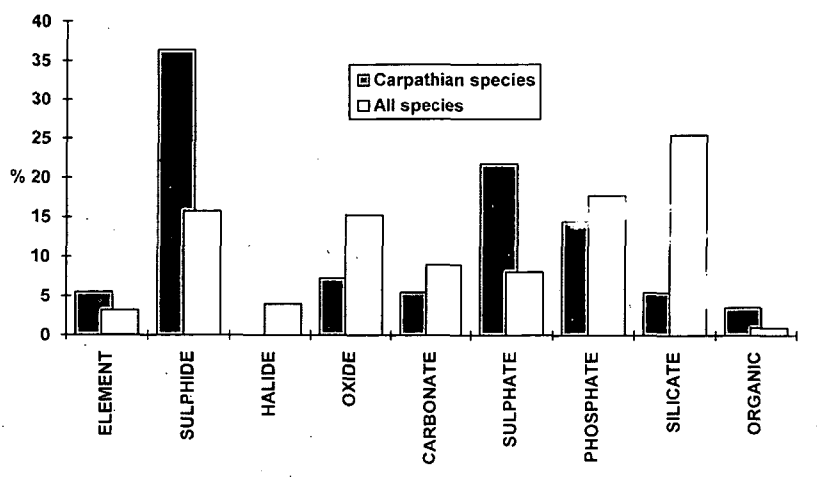

Fig. 1. Distribution of mineral species first described from the Carpathian area versus distribution of all species* among mineral classes (* percentages were counted on the basis of HÖLZEL, 1990)

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REFERENCES

CLARK, A. M. (1993): Hey's Mineral Index. Chapman & Hall, London, 852 pp.

DANA, E. S. (1892): The System of Mineralogy. John Wiley & Sons, New York, 1134 pp.

DELIENS, M. & STALDER, A. H. (1995): Mineral Species first described from Zaire and their Type Mineral Specimens. A Part of the Catalogue of Type Mineral Specimens. Studiedokumenten van het K.B.I.N., **77**, 29 pp.

ENZSEL, I. & GAZDA, S. (1978): Magyar ásványnevek eredete. Stúdium (Debrecen). **8**, pp. 71–79.

HINTZE, C. (1897–1968): Handbuch der Mineralogie. Bd. I–II., Ergänzungsbd. I–III. Veit & Co., Leipzig, later Walter de Gruyter, Berlin.

HÖLZEL, A. R. (1990): Systematics of minerals with several appendix. Author's publ. Ober-Olm (Mainz), 584 pp.

KOCH S. (1928): Magyar ásványok. Term.tud. Közl., **60**, pp. 63–68.

MUREŞAN, I., ŢÎRLEA-HOŢIU, I. & CÎMPEAN, A. V. (1990): Minerale din România, descrise prima dată în literature mondială (consideraţii generale). Studia Univ. Babeş-Bolyai, Geol., **25**, pp. 3–33.

NICKEL, E. H. & NICHOLS, M. C. (1991): Mineral Reference Manual. Van Nostrand Reinhold, New York. 250 pp.

NICOLESCU, Ş. (1996): List of valid and discredited mineral species and varieties, first described from Romania. pp. 37–43 in: Nicolescu, Ş.: Excursion Guide. Field Trip E1. Banat and Transylvanian Gold District, Romania. Budapest, Magyarhoni Földtani Társulat.

PALACHE, CH., BERMAN, H. & FRONDEL, C. (1944): The System of Mineralogy, Vol. I. John Wiley & Sons, New York. 834 pp.

PETERSEN, O. V. (1996): Encyclopedia of minerals for which Greenland is the type locality – from historical specimens to type specimens „sensu stricto". Acta Miner.-Petr. (Szeged), **37**, Suppl., p. 94.

RAADE, G. (1996): Minerals originally described from Norway – A historical survey. Acta Miner.-Petr. (Szeged), **37**, Suppl., p. 104.

STALDER, H. A., CIPRIANI, C. & HÖLZEL, A. R. (1994): Minerals first described in Italy and their type mineral specimens. IMA Commission on Museums, 57 pp.

STALDER, H. A., SEMENOV, E. I., MININA, E., EVSEEV, A. & HÖLZEL, A. R. (1996): Mineral species first described from Russia and the former Soviet Union. Acta Miner.-Petr. (Szeged), **37**, Suppl., p. 112.

STRUNZ, H. (1982): Mineralogische Tabellen. 8th edition. Leipzig, Akademische Verlagsgesellschaft Geest & Portig K.-G. 621 pp.

SZAKÁLL, S. & GATTER, I. (1993): Magyarországi ásványfajok. Fair System, Miskolc. 211 pp.

UDUBAŞA, G. (1992), ILINCA, GH., MARINCEA, ŞT., SĂBĂU, G. & RĂDAN, S. (1992): Minerals in Romania: the State of the Art 1991. Romanian Journal of Mineralogy, **75**, pp. 1–51.

TABLE 1 Valid* mineral species first described from the Carpathian area

species name	c	first described by	in	renamed by	in	type locality (recent name)	type locality (former names)	country
alabandite	2	Müller von Reichenstein, F.J.	1784	Beudant, F.S.	1832	Săcărâmb	Nagyág	ROM
alloclasite	2	Tschermak, G.	1868			Oraviţa Montană	Oravicabánya/Orawitza	ROM
andorite	2	Krenner, J.	1892			Baia Sprie	Felsőbánya	ROM
ardealite	6	Schadler, J.	1931			Cioclovina cave	Csoklovina	ROM
cohenite	1	Weinschenk, E.	1889			Slanická Osada (meteorite)	Szlanica/Slanica	SLK
cyanotrichite	6	Werner, G.A. in Karsten, D.L.G.	1808	Glocker, E.F.	1839	Moldova Nouă	Újmoldova	ROM
dietrichite	6	Schröckinger, J.	1878			Baia Sprie	Felsőbánya	ROM
euchroite	5	Breithaupt, A.	1823			Ľubietová	Libetbánya/Libethen	SLK
evansite	5	Forbes, D.	1864			Železník near Sirk	Vashegy (nr Szirk)	SLK
felsőbányaite	6	Kenngott, A.	1853			Baia Sprie	Felsőbánya	ROM
fizélyite	2	Krenner, J. & Loczka, J.	1913			Chiuzbaia	Kisbánya	ROM
fülöppite	2	Finály, I. & Koch, S.	1929			Baia Mare	Nagybánya	ROM
hauerite	2	Haidinger, W.	1847			Kalinka (part of Vígľašská Huta-Kalinka)	Végleskálnok/Kalinka	SLK
hodrushite	2	Koděra, M. et al.	1970			Banská Hodruša (part of Hodruša-Hámre)	Hodrusbánya/Hodritsch	SLK
hörnesite	5	Kenngott, A.	1860	Haidinger, W.	1860	Banat	Bánság	ROM
karpathite	9	Piotrovskiy, G.L.	1955			Оленеве (Oleneve)	Szarvaskút/Olenovo	UKR
klebelsbergite	6	Zsivny, V.	1929			Baia Sprie	Felsőbánya	ROM
koktaite	6	Sekanina, J.	1948			Žeravice u Kyjova	Žeravice u Kyjova	CZE
kornelite	6	Krenner, J.	1888			Smolník	Szomolnok/Schmöllnitz	SLK
krautite	5	Fontan, F. et al.	1975			Săcărâmb	Nagyág	ROM
krennerite	2	Krenner, J.	1877	vom Rath, G.	1877	Săcărâmb	Nagyág	ROM
libethenit	5	Leonhard, C.C.	1812	Breithaupt, A.	1823	Ľubietová	Libetbánya/Libethen	SLK
ludwigite	7	Tschermak, G.	1874			Ocna de Fier	Vaskő/Moravicza	ROM
makovickyite	2	Žák, L. et al.	1994			Băiţa (Bihor)	Rézbánya	ROM
mátraite	2	Koch S.	1958			Gyöngyösoroszi	Gyöngyösoroszi	HUN
merrihueite	4	Dodd, R.T. et al.	1965			Mădăraş (meteorite)	Mezőmadaras/Madaras	ROM
monsmedite	6	Götz, A. et al. in: Manilici, V. et al.	1965			Baia Sprie	Felsőbánya	ROM
mrázekite	5	Řídkošil, T. et al.	1992			Ľubietová	Libetbánya/Libethen	SLK
muthmannite	2	Zambonini, F.	1911			Săcărâmb	Nagyág	ROM
nagyágite	2	Scopoli, G.	1769	Haidinger, W.	1845	Săcărâmb	Nagyág	ROM

species name	c	first described by	in	renamed by	in	type locality (recent name)	type locality (former names)	country
paděraite	2	Mumme, W.G. & Žák, L.	1985			Băiţa (Bihor)	Rézbánya	ROM
parajamesonite	2	Zsivny, V. & Náray-Szabó, I.	1947			Herja mine (near Chiuzbaia)	Herzsa-bánya (nr Kisbánya)	ROM
petzite	2	Petz, W.	1842	Haidinger, W.	1845	Săcărâmb	Nagyág	ROM
pilsenite	2	Born, I.	1790	Kenngott, A.	1853	Nagybörzsöny	Nagybörzsöny/Deutschpilsen	HUN
pseudobrookite	3	Koch A.	1878			Uroi	Arany	ROM
rhodochrosite*	7	Bergman, T.	1780	Hausmann, J.F.L.*	1813	Săcărâmb (*Cavnic)	Nagyág (*Kapnikbánya)	ROM
rhodonite*	4	Ruprecht, A.	1783	Jasche, C.F.* in Germar, E.F.	1819	Cavnic (*Elbingerode, GER)	Kapnikbánya (*Elbingerode, GER)	ROM
rhomboclase	6	Krenner, J.	1891			Smolník	Szomolnok/Schmöllnitz	SLK
rozenite	6	Kubisz, J.	1960			Mt. Ornak and Rudki	Mt. Ornak and Rudki	POL
rutile	3	Born, I.	1772	Werner, G.A. in Ludwig, C.F.	1803	Revúca (?)	Nagyrőce/Rauschenbach (?)	SLK
schafarzikite	3	Krenner, J.	1915			Pernek	Pernek	SLK
schreibersite	1	Haidinger, W.	1847			Slanická Osada (meteorite)	Szlanica/Slanica	SLK
semseyite	2	Krenner, J.	1881			Baia Sprie	Felsőbánya	ROM
stützite	2	Schrauf, A.	1878			Săcărâmb?	Nagyág?	ROM
sylvanite	2	Gerhard, C.A.	1786	Necker, L.A.	1835	Baia de Arieş	Aranyosbánya/Offenbánya	ROM
syngenite	6	Zepharovich, V.	1872			Калуш (Kalush)	Kalusz	UKR
szaibélyite	7	Peters, C.	1861			Băiţa (Bihor)	Rézbánya	ROM
szmikite	6	Schröckinger, J.	1877			Baia Sprie	Felsőbánya	ROM
szomolnokite	6	Krenner, J.	1891			Smolník	Szomolnok/Schmöllnitz	SLK
tellurite	3	Petz, W.	1842	Haidinger, W.	1845	Faţa Băii near Zlatna	Facebánya/Facebay (nr Zalatna)	ROM
tellurium	1	Müller von Reichenstein, F.J.	1785	Klaproth, M.H.	1802	Faţa Băii near Zlatna	Facebánya/Facebay (nr Zalatna)	ROM
tetradymite	2	Wehrle, A.	1830	Haidinger, W.	1831	Župkov	Erdősurány/Zsubkó/Schubkau	SLK
vashegyite	5	Zimányi, K.	1909			Železník near Sirk	Vashegy (nr Szirk)	SLK
veszelyite	5	Schrauf, A.	1874			Ocna de Fier	Vaskő/Moravica	ROM
whewellite	9	Brooke, H.J.	1840	Brooke, H.J. & Miller, W.H.	1852	Cavnic??	Kapnikbánya??	ROM??
wollastonite*	4	Stütz, A.	1793	Léman, J.*	1818	Ciclova Montană (*Capo di Bove, ITA)	Csiklovabánya/Cziklowa (*Capo di Bove, ITA)	ROM

* Generally accepted and officially not discredited species (before 1959); species approved by IMA CNMMN (after 1959).
c: Mineral classes; 1: elements (incl. carbides, etc.), 2: sulphides (incl. tellurides, etc.), 3: oxides, 4: silicates, 5: phosphates (incl. arsenates), 6: sulphates, 7: borates, 8: halides (none), 9: organic minerals
the species was renamed using a specimen from another locality
abbreviations: nr: near, CZE: Czech Rep., HUN: Hungary, POL: Poland, ROM: Romania, SLK: Slovakia, UKR: Ukraine

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MINERALS OF HUNGARY, STATE OF THE ART IN 1996

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ABSTRACT

After a historical introduction, and a discussion on the reliability of data and the documentation of samples a tabulated list of the mineral species described from Hungary is given. Species names are arranged alphabetically by classes (except for silicates, which are subdivided to subclasses). The species that were included in the second (1985) edition of *Magyarország ásványai* (Minerals of Hungary) of Sándor Koch („KMH2 species") and the species that were not mentioned by this work („post-KMH2 species") are listed separately. Uncertain KMH2 species are given as an appendix to the list of the KMH2 species. Some 440 valid mineral species are known from Hungary at present. The number of the known species has nearly doubled in the last decade, the increase was especially high among the arsenates and halides.

1. HISTORICAL INTRODUCTION

The minerals of the present territory of Hungary was reviewed first by KOCH (1927) in a short paper. Later he published a monographical treatise of the minerals of Hungary. While the first edition of his monograph (KOCH, 1966) was entirely his work, the second edition (KOCH, 1985, referred here as KMH2) was edited by József Mezősi.

In the 1980's two manuscript volumes of the „Mineralogical Encyclopaedia of Hungary" (PAPP & WEISZBURG, 1986; MOLNÁR & PAPP, 1990) were prepared by the staff of the Dept. of Mineralogy, Eötvös L. University (Budapest). This research brought forward a great deal of old, almost forgotten information; however, the real importance of these compilations was the critical review of the available data and the separate discussion of the uncertain descriptions. It is to be noted, that the most uncertain data were listed as well.

In the last decade the number of mineral species of Hungary considerably increased, most of the new ones („post-KMH2 species") were mentioned first by SZAKÁLL & GATTER (1993). That book and this paper attempt to keep a critical approach similar to that of the „Mineralogical Encyclopaedia of Hungary".

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2. THE HUNGARIAN MINERAL SPECIES IN KMH2 AND TODAY

2.1. REMARKS ON THE RELIABILITY OF DATA – „CERTAIN" AND „UNCERTAIN" SPECIES

The reliability of the data on the presence of the different mineral species in Hungary is different. On one hand it depends on our knowledge on the specific mineral occurrence: the accuracy of the published descriptions, the quantity and quality of the experimental and other investigations, etc.; on the other it depends on the difficulties of the identification of the given species in general. It is impossible to establish exact and overall criteria for the reliability of the data, every judgement is unavoidably subjective. However, for every species it is necessary to draw a line somewhere to separate the certain and the uncertain (doubtful) occurrences.

In this way we classified the KMH2 species into two categories: certain and uncertain (doubtful) ones, both groups are listed separately in this paper. The same principle was applied to the post-KMH2 species, but the uncertain ones are not listed here. The importance of this critical approach is demonstrated on two examples of the general use of uncertain data.

In the 1950s lemon-yellow, pulverulent coatings were found on calcite crystals in prospecting adits near Parádsasvár (Mátra Mts.). This material was mentioned as greenockite in KMH2; however, it is not known what studies this statement is based on. It is still unclear whether the few μm-size Cd- and S-bearing aggregates in the coatings correspond to greenockite or hawleyite (or other??). In spite of the lack of any proof the mineral is regarded as greenockite by all Hungarian scientific and popular mineralogical books (it even appeared as greenockite on a postage-stamp).

There is a similar situation with cervantite: it is mentioned in several older publications as an alteration product of stibnite from different Hungarian localities. Nevertheless, X-ray studies of such products proved the presence of other antimony oxide minerals but cervantite. This fact certainly does not exclude the existence of cervantite in Hungary; however, the earlier references has not been proven yet.

Two kinds of uncertain species are distinguished here. One question-mark (?) denotes those KMH2 species that are first qualified as uncertain in *this paper*. In *our opinion* these species were published with insufficient (or without any) data. For example in some cases the published results made only possible the classification of the material into a mineral group instead of the usage of a species name.

Two question-marks (??) denote those KMH2 species that were qualified as uncertain already in the *original paper*. These species were regarded as doubtful ones by *the authors of the original paper*. Hence, the double-queried species are more doubtful than the single-queried ones.

2.2. REMARKS ON POST-KMH2 SPECIES

Those minerals that were denoted in the KMH2 with group (or series) names (apophyllite, olivine, tourmaline, etc.) are omitted from this paper. Some of these minerals were re-examined and classified according to the existing international nomenclatural rules, and they are listed among the post-KMH2 species.

It is to be noted that some species are listed among the post-KMH2 species in spite of their publication predates 1985 (year of publication of KMH2), because they were not included in KMH2 for various reasons.

2.3. REMARKS ON THE DOCUMENTATION OF THE SAMPLES

During the compilation of the species lists we attempted the re-examination and classification of the uncertain species and those minerals that were originally described only on group level. In many cases the lack of the original (or at least equivalent) samples made this attempt impossible. Therefore it is strongly recommended that the authors should always send samples from scientifically interesting mineral species and parageneses to public collections. It is also highly desirable that all samples containing rare or previously unknown mineral species from Hungarian localities should also get into public collections. This is of essential importance in the case of unique, irreplaceable specimens.

The importance of adequate documentation and preservation of even the smallest samples from unique specimens has already been recognised on international level. In some descriptive sciences only those publications are approved, whose object (material) is adequately documented, deposited and inventoried in a public collection. The survival of the samples in the sample collection of the researchers or of the researchers' institute is usually uncertain, and even in this case the inadequate specimen labelling used by the researchers frequently makes the specimen useless.

For the demonstration of the importance of the adequate documentation and preservation of samples, the name of those Hungarian mineral species that are missing from the Hungarian public collections are printed in italics in our species list. Out of about 440 Hungarian mineral species there is no sample of some 50 species in the Hungarian public mineral collections (according to their inventories). It is practically impossible to perform further studies on these species for lack of samples. (It is to be noted that the identification of the unpublished species listed in this paper is based on detailed studies on documented and inventoried samples, which are available for further research.)

3. INTRODUCTION TO THE TABLES

Species names are arranged alphabetically by classes (except for silicates, which are subdivided to subclasses). Only those species are included that are considered as valid species by relevant mineralogical handbooks (e.g. Fleischer & Mandarino, 1995; Nickel & Nichols, 1991) and the IMA CNMMN resolutions. In each class the species that were included in the second (1985) edition of *Magyarország ásványai* (Minerals of Hungary) of Sándor Koch are tabulated first („KMH2 species"). Uncertain KMH2 species are given as an appendix to this list.

In each class a second list comprises the species that were not mentioned by Koch (1985), („post-KMH2 species"). Reference is always given to the first paper containing satisfactory data on the existence of the given species. In the case of unpublished species the author of the first unpublished study with reliable data and adequate sample documentation is quoted.

According to these lists some 440 mineral species are known from Hungary at present. It can be stated that the number of the Hungarian species has considerably increased since

the publication of KMH2. The number of the species has nearly doubled, the increase was especially high among the arsenates and halides.

NATIVE ELEMENTS

KMH2 Native Elements

arsenic
bismuth
copper
gold
mercury
sulphur
tellurium

Uncertain species: ??platinum

Post-KMH2 Native Elements

antimony (Nagy, 1986)
cohenite (Buchwald, 1975)
graphite (Árkai, Horváth & Tóth, 1981)
haxonite (Buchwald, 1975)
iron (Sztrókay, Tolnay & Földvári-Vogl, 1961)
kamacite (Mauritz, Hegedűs & Szelényi, 1953)
moschellandsbergite (Szakáll & Kovács, 1995)
schreibersite (Buchwald, 1975)
silver (Szakáll & Kovács, 1995)
taenite (Mauritz, Hegedűs & Szelényi, 1953)

SULPHIDES

KMH2 Sulphides

acanthite
arsenopyrite
bismuthinite
bornite
boulangerite
bournonite
chalcocite
chalcopyrite
chalcostibite
cinnabar
cobaltite
cosalite
covellite
emplectite
enargite
freibergite
galena
hessite
idaite
joséite-A
löllingite
luzonite
marcasite
mátraite
metacinnabar
molybdenite
nickeline
orpiment
pentlandite
pilsenite
proustite
pyrargyrite
pyrite
pyrrhotine
realgar
seligmannite
semseyite
sphalerite
stannite
stephanite
stibnite
tellurobismuthite
tennantite
tetradymite
tetrahedrite
wittichenite
wurtzite

Uncertain species: ?berthierite, ?clausthalite, ??cubanite, ?famatinite, ??ferroselite, ?galenobismutite, ??gersdorffite, ?greenockite, ??guanajuatite, ?hauchecornite, ?jamesonite, ?lautite, ??meneghinite, ??miargyrite, ??millerite, ?montbrayite, ?nagyágite, ?petzite, ??sartorite, ?schapbachite, ??sternbergite, ?sylvanite, ?vaesite, ?valleriite

Post-KMH2 Sulphides

altaite (First, unpublished)
arsenosulvanite (Dobosi, 1984)
calaverite (Nagy, 1985)
capgaronnite (Sarp & Szakáll, unpublished)
coloradoite (First, unpublished)
colusite (First, unpublished)
cubanite (Dódony, 1986)
digenite (Pósfai, 1990)
djurleite (Pósfai, 1990)
domeykite (Szakáll, 1992a)
famatinite (Dobosi & Nagy, 1993)
fizélyite (Dobosi & Nagy, 1984)
galenobismutite (Nagy & Dobosi, in press)
gersdorffite (Szakáll et al., unpublished)
glaucodot (Nagy, 1990)
goldfieldite (Dobosi & Nagy, 1993)
greenockite (Dódony & Szakáll, unpublished)
heazlewoodite (Ghoneim & Szederkényi, 1979)
heteromorphite (Nagy, 1986)
joséite-B (Weiszburg, unpublished)
késterite (Dobosi, 1984)
krennerite (Nagy, 1985)
kuramite (First, unpublished)
lillianite (Dobosi & Nagy, 1984)
mawsonite (First, unpublished)
melonite (Weiszburg et al., unpublished)
miargyrite (Horváth, 1987)
millerite (Nemecz, 1956)

petzite (First, unpublished)
polybasite (Szakáll et al.,1994e)
skinnerite (Szakáll et al., unpublished)
stannoidite (First, unpublished)
sylvanite (First, unpublished)
troilite (Dódony, 1986)
xanthoconite (Szakáll et al., 1994e)

HALOIDS
KMH2 Haloids
fluorite
halite

Post-KMH2 Haloids
bischofite (Szakáll et al., unpublished)
bromargyrite (Szakáll & Kovács, 1995)
chlorargyrite (Szakáll et al., 1994c)
eriochalcite (Szakáll et al., unpublished)
iodargyrite (Szakáll & Kovács, 1995)
paratacamite (Szakáll, 1992a)
perroudite (Sarp & Szakáll, unpublished)
sal ammoniac (Szakáll, 1989)
sylvite (Molnár & Takács, 1993)

OXIDES
KMH2 Oxides
anatase
arsenolite
baddeleyite
bindheimite
böhmite
brannerite
brucite
chromite
clarkeite
corundum
cristobalite
cryptomelane
cuprite
diaspore
gibbsite
goethite
groutite
hematite
ilmenite
lepidocrocite
lithiophorite
magnetite
manganite
nsutite
opal
pyrolusite
quartz
ramsdellite
romanèchite
rutile
schoepite
senarmontite
spinel
tenorite
todorokite
tridymite
uraninite
valentinite

Uncertain species: ??bauranoite, ?becquerelite, ?brookite, ?cervantite, ?curite, ??fourmarierite, ?ianthinite, ?maghemite, ?metacalciouranoite, ?montroseite, ?nordstrandite, ?russellite, ?tellurite, ?thorianite, ??zirkelite

Post-KMH2 Oxides
bayerite (Náray-Szabó & Péter, 1967)
cassiterite (Szakáll & Kovács, 1993)
cerianite (Pantó, 1975)
claudetite (Koch, 1966)
delafossite (Szakáll & Jánosi, unpublished)
ferberite (Szakáll et al., 1995)
hercynite (Török, 1993)
hübnerite (Szakáll et al., 1995)
ice
maghemite (Mindszenty et al., unpublished)
magnesiochromite (Embey-Isztin et al., 1989)
nordstrandite (Náray-Szabó & Péter, 1967)
perovskite (Pantó, 1975)
portlandite (Szakáll & Kovács, 1992)
pseudobrookite (Szakáll, 1992b)
rancièite (Szakáll, 1992a)
stibiconite (Jánosi & Papp, 1985)
thorianite (Pantó, 1975)
tripuhyite (Sajó, unpublished)
ulvöspinel (Harangi & Árva-Sós, 1993)

CARBONATES
KMH2 Carbonates
andersonite
ankerite
aragonite
azurite
bastnäsite-(Ce)
calcite
cerussite
dawsonite
dolomite
huntite
liebigite
magnesite
malachite
otavite
rhodochrosite
scarbroite
siderite
smithsonite
vaterite

Uncertain species: ?alumohydrocalcite, ?kutnohorite, ??parisite-(Ce), ??röntgenite-(Ce), ?swartzite, ??synchysite-(Ce)

Post-KMH2 Carbonates

aurichalcite (Szakáll, 1992a)
claraite (Szakáll et al., unpublished)
dypingite (Kiss & Jánosi, 1994)
hydromagnesite (Bognár, 1986)
hydrotalcite (Papp, 1988)
hydrozincite (Szakáll, 1992a)
kutnohorite (Grasselly et al., 1985)
nesquehonite (Kiss & Jánosi, 1994)
niter (Kvassay, 1876)
northupite (Kiss & Jánosi, 1994)
rosasite (Szakáll et al., unpublished)
synchysite-(Ce) (Szakáll, 1992a)
trona (Szakáll et al., unpublished)
zincrosasite (Várhegyi, unpublished)

SULPHATES

KMH2 Sulphates

aluminite
alunite
alunogen
anglesite
anhydrite
barite
basaluminite
bassanite
brochantite
celestine
chalcanthite
copiapite
epsomite
glauberite
goslarite
gypsum
halotrichite
hexahydrite
jarosite
kalinite
melanterite
mendozite
parabutlerite
rozenite
scheelite
szomolnokite
tschermigite
uranopilite
zippeite

Uncertain species: ??argentojarosite, ??kröhnkite

Post-KMH2 Sulphates

antlerite (Szakáll, 1992a)
blödite (Kiss & Jánosi, 1994)
bonattite (Szakáll et al., in press)
botryogen (Szakáll et al., in press)
coquimbite (Szakáll et al., in press)
devilline (Szakáll et al., in press)
fibroferrite (Szakáll et al., in press)
fornacite (Szakáll et al., in press)
hydronium jarosite (Papp, 1990)
koktaite (Szakáll et al., in press)
letovicite (Szakáll, 1992a)
linarite (Szakáll et al., in press)
magnesiocopiapite (Szakáll et al., in press)
mascagnite (Szakáll, 1992a)
millosevichite (Szakáll et al., in press)
mirabilite (Szatmári, 1966)
natrojarosite (Papp, 1990)
pickeringite (Szakáll et al., in press)
plumbojarosite (Szakáll et al., 1994b)
posnjakite (Szakáll, 1992a)
rhomboclase (Viczián et al., 1986)
römerite (Szakáll et al., in press)
sideronatrite (Szakáll et al., in press)
siderotil (Szakáll et al., in press)
slavíkite (Szakáll et al., in press)
starkeyite (Szakáll et al., in press)
strontianite (Miklós, 1987)
tamarugite (Szakáll, 1992a)
thénardite (Kiss & Jánosi, 1994)
voltaite (Szakáll et al., in press)

PHOSPHATES AND ARSENATES

KMH2 Phosphates and arsenates

autunite
beraunite
brushite
cacoxenite
carbonate-hydroxylapatite
cheralite
crandallite
fermorite
florencite-(Ce)
fluorapatite
kingite
koninckite
lazulite
meta-autunite
monazite-(Ce)
pyromorphite
vashegyite
vivianite
wavellite
xenotime-(Y)

Uncertain species: ??carnotite, ?delvauxite, ?saléeite, ?tyuyamunite

Post-KMH2 Phosphates and arsenates

annabergite (Szederkényi, 1962)
arseniosiderite (Szakáll et al., 1994a)
bayldonite (Szakáll et al., unpublished)
beudantite (Szakáll et al., 1994a)
conichalcite (Szakáll et al., 1994a)
diadochite (Földvári & Nagy, 1985)
gorceixite (Szentpétery et al., 1989)
kaňkite (Szakáll et al., unpublished)
mimetite (Szakáll & Kovács, 1994)
monetite (Sztrókay, 1959)

olivenite (Szakáll et al., 1994a)
pharmacosiderite (Szakáll et al., 1994a)
picropharmacolite (Szakáll et al., 1994a)
rhabdophane-(Ce) (Nagy G., unpublished)
saléeite (Kiss, 1961)
scorodite (Szakáll et al., 1994a)
segnitite (Szakáll et al., 1994a)
talmessite (Szakáll et al., 1994a)
taranakite (Szakáll & Jánosi, 1993)
tyrolite (Szakáll et al., 1994a)
variscite (Szakáll et al., 1994d)

NESOSILICATES
KMH2 Nesosilicates

almandine
andalusite
andradite
coffinite
forsterite
kasolite
kyanite
soddyite
staurolite
thaumasite
thorite
titanite
topaz
uranophane
zircon

Uncertain species: ?pyrope, ?spessartine

Post-KMH2 Nesosilicates
chloritoid (Noske-Fazekas, 1973)
datolite (Szakáll et al., unpublished)
fayalite (Buda, 1993)
grossular (Soós et al., 1991)
mullite (Sztrókay, 1986)
pyrope (Török, 1995)
schorlomite (Horváth & Ódor, 1984)
sillimanite (Mauritz, 1909)
spessartine (Török, unpublished)

SOROSILICATES
KMH2 Sorosilicates

allanite-(Ce)
bertrandite
epidote
hemimorphite
vesuvianite
zoisite
zunyite

Uncertain species: ?clinozoisite

Post-KMH2 Sorosilicates
clinozoisite (Török, unpublished)
ferro-axinite (Szakáll, 1993)
gehlenite (Dódony & Jánosi, unpublished)
pumpellyite (Árkai, 1973)

CYCLOSILICATES
KMH2 Cyclosilicates

beryl
cordierite
schorl

Uncertain species: ?elbaite , ?osumilite

Post-KMH2 Cyclosilicates
dravite (Demény, 1987)
roedderite (Török & Szakáll, unpublished)

INOSILICATES
KMH2 Inosilicates

actinolite
augite
diopside
enstatite
inesite
kaersutite
prehnite
tremolite
wollastonite

Post-KMH2 Inosilicates
aegirine (Mauritz, 1913)
crossite (Kubovics, 1983)
edenite (Harangi, unpublished)
glaucophane (Lelkes-Felvári, 1982)
grunerite (Buda, 1993)
hedenbergite (Dódony & Gatter, 1988)
magnesiohastingsite (Harangi, unpublished)
magnesiohornblende (Harangi, unpublished)
nekoite (Sajó, unpublished)
okenite (Sajó, unpublished)
pectolite (Szakáll et al., unpublished)
pigeonite (Soós & Dódony, 1989)
tobermorite (Papp, 1988)
tschermakite (Harangi, unpublished)

PHYLLOSILICATES

KMH2 Phyllosilicates

antigorite
biotite
celadonite
chamosite
clinochlore
clinochrysotile
cronstedtite
dickite
glauconite
halloysite
illite
kaolinite
lizardite
montmorillonite
muscovite
nontronite
orthochrysotile
palygorskite
pyrophyllite
saponite
sudoite
talc

Uncertain species: ?amesite, ?brammallite, ?chrysocolla, ?donbassite, ?hydrobiotite, ?metahalloysite, ??nacrite, ?phlogopite, ?sepiolite, ?stilpnomelane

Post-KMH2 Phyllosilicates

annite (Török, 1996)
beidellite (Varga–Máthé, 1966)
caryopilite (Dódony & Gatter, 1986)
chrysocolla (Szakáll & Földvári, 1996)
clintonite (Fehér, unpublished)
corrensite (Viczián, 1993)
fluorapophyllite (Szakáll et al., unpublished)
hisingerite (Szakáll et al., unpublished)
paragonite (Felvári & Viczián, 1972)
phlogopite (Szabó, 1985)
rectorite (Nemecz et al., 1963)
sepiolite (Nemecz, unpublished)
stilpnomelane (Árkai et al., 1981)
vermiculite (Raincsák–Kosáry, 1978)

TECTOSILICATES

KMH2 Tectosilicates

albite
analcime
chabazite
clinoptilolite
epistilbite
garronite
gismondine
gmelinite
gonnardite
heulandite
laumontite
leucite
levyne
mesolite
mordenite
natrolite
orthoclase
phillipsite
sanidine
scolecite
stilbite
tetranatrolite
thomsonite

Post-KMH2 Tectosilicates

anorthite (Pantó, 1974)
anorthoclase (Vincze–Szeberényi, 1982)
dachiardite (Szakáll, 1992c)
ferrierite (Szakáll, 1992c)
harmotome (Szakáll, 1992b)
meionite (Török, 1994)
microcline (Buda, 1969)
nepheline (Mauritz, 1913)
offretite (Szakáll & Jánosi, unpublished)
sodalite (Mauritz, 1913)
stellerite (Jánossy et al., 1987)
yugawaralite (Rappensberger, 1991)

ORGANIC MINERALS

KMH2 Organic minerals

mellite
whewellite

Post-KMH2 Organic minerals

humboldtine (Weiszburg et al., unpublished)

REQUEST TO THE READER

The author is grateful for any information that may complete this compilation (interesting samples, forgotten or unpublished results, papers that escaped our attention, etc.).

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REFERENCES

ÁRKAI, P. (1973): Pumpellyite-prehnite-quartz facies alpine metamorphism in the Middle Triassic volcanogenic-sedimentary Sequence of the Bükk Mountains, Northeast Hungary. Acta Geol., 17, 67–83.

ÁRKAI, P., HORVÁTH, Z. & TÓTH, M. (1981): Transitional very low- and low-grade regional metamorphism of the Paleozoic Formations, Uppony Mountains, NE-Hungary: mineral assemblages, illite-crystallinity, to and vitrinite reflectance data. Acta Geol., 24, 265–294.

BOGNÁR, L. (1986): Ásványérdekességek kristálybarlangjainkból. Ásv. gyűjtő Figyelő, 3/2, 16–18.

BUCHWALD, V. D. (1975): Handbook of Iron Meteorites. vol. 3. Univ. California Press.

BUDA, GY. (1969): Genesis of the granitoid rocks of the Mecsek and Velence Mountains on the basis of the investigation of the Feldspars. Acta Geol., 13, 131–155.

BUDA, GY. (1993): Enclaves and fayalite-bearing pegmatitic „nests" in the upper part of the granite intrusion of the Velence Mts., Hungary. Geol. Carpathica, 44/3, 143–153.

DEMÉNY, A. (1987): Turmalinszemcsék geokémiai vizsgálata (Kőszegi-hegység).(Geochemical studies of tourmaline grains (Kőszeg Mts). Földt. Közl., 117/2., 131–140.

DOBOSI, G. (1981): MTA GKL 47/G/1981. sz. kutatási jelentés. Kézirat. MTA GKL.

DOBOSI, G. (1982): MTA GKL 65/G/1982. sz. kutatási jelentés. Kézirat. MTA GKL.

DOBOSI, G. (1984): MTA GKL 96/G/1984. sz. kutatási jelentés. Kézirat. MTA GKL.

DOBOSI, G. (1984): MTA GKL 100/G/1984. sz. kutatási jelentés. Kézirat. MTA GKL.

DOBOSI, G. & NAGY, B. (1993): Contributions to the mineralogy of the Lahóca hydrothermal ore deposits of Recsk, North Hungary. Ann. Report of the Hung. Geol. Survey, 1991, 289–320.

DOBOSI, G. & NAGY, B. (in press): Composition and variation of fahlore minerals in the hydrothermal ore deposits of Hungary. Ann Report of the Hung. Geol. Survey.

DÓDONY, I. (1994): A recski pirrhotin minták képződési hőmérsékletének lehatárolása. Kutatási jelentés, Kézirat. OÉÁ. SzM-6/1984.

DÓDONY, I. & GATTER, I. (1986): A gyöngyösoroszi ércesedés ásványtani-teleptani-genetikai vizsgálata. Kutatási jelentés, Kézirat. KFH. SzM-3/1986.

DÓDONY, I. & GATTER, I. (1988): A recski Cu-porfir teleptest és az ércesedést kísérő kőzetek szilikát ásványainak genetikai célú ásványtani, szöveti vizsgálata. Kutatási jelentés, Kézirat. KFH.

EMBEY-ISZTIN, A., SCHARBERT, H. G., DIETRICH, H. & POULTIDIS, H. (1989): Petrology and geochemistry of peridotite xenoliths in alkali basalts from the Transdanubian Volcanic Region, West Hungary. J. Petrology, 30, 79–105.

FELVÁRI, GY. & VICZIÁN, I. (1972): Koegzisztens paragonit-muszkovit a Kőszegi-hegység metamorf kőzeteiben.(Coexistent paragonite-muscovite in the metamorphic rocks of the Kőszeg Mountains). Földt. Közl., 103/1, 19–26.

FLEISCHER, M. & MANDARINO, J. A. (1995): Glossary of Mineral Species 1995. The Mineralogical Record Inc. Tucson. 280.

FÖLDVÁRI, M. & NAGY, B. (1985): Desztinezit és diadochit Mátraszentimréről. Földt. Közl., 115, 123–131.

GHONEIM, M. F. & SZEDERKÉNYI, T. (1979): Petrological rewiev of the Ófalu Serpentinite, Mecsek Mountains, Hungary. Acta Miner.Petr., Szeged, 35/1. 5–18.

GRASSELLY, GY., POLGÁRI, M., TÓTH, M., PÁPAI, L., MOLNÁR, E. & GEIGER, J. (1985): Hazai mangántelepek genetikai és hasznosítási kérdéseinek komplex geokémiai és ásvány-kőzettani vizsgálata. Kutatási jelentés. Kézirat. MGSZ Adattár.

HARANGI, SZ. & ÁRVA-SÓS, E. (1993): A Mecsek hegység alsókréta vulkáni kőzetei I. Ásvány- és kőzettan. Acta Miner. Petr., Szeged, 123/2, 129–165.

HORVÁTH, I. & ÓDOR, L. (1984): Alkaline ultrabasic rocks and associated silicocarbonatites in the NE part of the Transdanubian Mts. (Hungary) Mineralia Slov. 16/1, 115–119.

HORVÁTH J. (1987): Új kutatási módszer felhagyott bányavágatok vizsgálatára. Éves beszámolójelentés. Kézirat. MONTAN GM. Budapest.
JÁNOSI, M. & PAPP, G. (1985): Sztibikonit és antimonit Rátkáról. Ásv. gyűjtő Figyelő. II/4. 18–22.
JÁNOSSY, A., OLASZI, V. & VÁRHEGYI, GY. (1987): Új zeolit-előfordulások Magyarországon. Hazai természetes zeolitok kutatása és felhasználása II. MTA VEAB. Veszprém. 9–25.
KISS, J. (1961): A mecseki uránérctelep ásványos alkata és genezise. Kandidátusi értekezés. Kézirat. ELTE. Budapest.
KISS, J. & JÁNOSI, M. (1994): Mg-minerals of recent hydrothermal formations of the Cu-porphyric mineralization at Recsk. Acta Miner. Petr., Szeged, 34, 7–19.
KOCH, S. (1927): Trianoni Magyarország ásványai. Term. tud. Közl. 45–48.
KOCH, S. (1966): Magyarország ásványai. Akadémiai kiadó, Budapest. 419.
KOCH, S. (1985): Magyarország ásványai. II. javított kiadás. (szerk. Mezősi J.). Akadémiai kiadó, Budapest. 562.
KUBOVICS, I. (1983): A nyugat-magyarországi crossitit kőzettani jellemzői és genetikája. Földt. Közl., 113/3. 207–224.
KVASSAY, E. (1876): Ueber den Natron- und Székboden im Ungarischen Tieflande. Jahrbuch K. u. K. Geologischen Reichsanstalt. B. 26. 427–445.
LELKES-FELVÁRI, GY. (1982): A contribution to the knowledge of the Alpine metamorphism in the Kőszeg-Vashegy area (Western Hungary). N. Jb. Geol. Paläont. Mh. 5., 297–305.
MAURITZ, B. (1909): A Mátra-hegység eruptiv kőzetei. MTA kiadása. Budapest. 1–80.
MAURITZ, B. (1913): A Mecsek-hegység eruptívus kőzetei. M. Kir. Földt. Int. Évk. 21/6. 154–190.
MAURITZ, B., HEGEDŰS, M. & SZELÉNYI, T. (1953): A kisvarsányi meteorkő. Földt. Közl., 83,/4–6, 138–144.
MIKLÓS, G. (1987): Az alsótelekesi gipsz- és anhidritelőfordulás ásvány-kőzettani, földtani-teleptani és hegységszerkezeti vizsgálata. Egyetemi doktori értekezés. Kézirat. Miskolci Egyetem.
MOLNÁR, F. & PAPP, G. (1990): Magyarországi oxidok és hidroxidok kritikai átnézete. I–II. Kézirat. KFH. Budapest.
NAGY, B. (1984): A Börzsöny-hegységi hidrotermális ércesedések komplex ércföldtani és geokémiai vizsgálata. Kandidátusi értekezés. Kézirat. MTA Adattár.
NAGY, B. (1985): Arany-, ezüst- és bizmuttelluridok a Parádfürdői ércesedés ásványparagenezisében. MÁFI Évi Jel. az 1983. évről. 321–357.
NAGY, B. (1986): A Gyöngyösoroszi ércesedés ásványtani felépítése. MÁFI Évi Jel. az 1984. évről. 403–423.
NAGY, B. (1990): Nagyirtáspusztai ércesedés (Börzsöny hegység). MÁFI Évi Jel. az 1988. évről. 277–325.
NAGY, B. & DOBOSI, G. (in press): Bismuth minerals from Rudabánya. Ann. Report of the Hung. Geol. Survey.
NÁRAY-SZABÓ, I. & PÉTER, É. (1967): Nachweis von Nordstrandit und Bayerit in Ungarischen Ziegeltonen. Acta Geol., 11, 375–377.
NEMECZ, E. (1956): A perkupai szerpentin ásványtani és geokémiai vizsgálata. Földt. Közl., 86, 424–434.
NEMECZ, E., VARJÚ, GY. & BARNA, J. (1963): Allevardite from Királyhegy, Tokaj Mountains, Hungary. Proc. Intern. Clay Conf. Stockholm. 2, 51–67.
NEMECZ, E. (1973): Agyagásványok. Akadémiai kiadó. Budapest. 507.
NICKEL, E. H. & NICHOLS, M. C. (1991): Mineral Reference Manual. Van Nostrand Reinhold. New York. 250.
NOSKE-FAZEKAS, G. (1973): Mikroszkópos megfigyelések az Upponyi-hegység paleozoos rétegösszletén. Fragm. Min. Pal., 4, 3–16.
PANTÓ, GY. (1974): Elektron mikroszonda vizsgálatok. Kutatási jelentés. MTA GKL. Budapest.
PANTÓ, GY. (1975): Trace minerals of the granitic rocks of the Velence and Mecsek Mountains. Acta Geol., 19, 59–93.
PAPP, G. & WEISZBURG, T. (1986): A magyarországi terméselemek és szulfidok kritikai átnézete. Kézirat. KFH. Budapest.
PAPP, G. (1988): Szerpentinásványok mineralógiai vizsgálata különös tekintettel a honi előfordulásokra. Egyetemi doktori értekezés. Kézirat. ELTE. Budapest.
PAPP, G. (1990): Szulfát ásványtársulás Tokodról. Földt. Közl., 120/1–2, 83–89.
RAINCSÁK-KOSÁRY, ZS. (1978): A Szendrői-hegység devon képződményei. Geol. Hung. Ser. Geol., 18, 1–113.
RAPPENSBERGER, CS. (1991): Mineralogical Identification of Zeolites in a Deep-Drilling Covre. PhD. Thesis. Manuscript. Univ. of Veszprém.
PÓSFAI, M. (1990): Rétegződés és kationrendeződés szoros illeszkedésű szulfidásvány szerkezetekben. Egyetemi doktori értekezés. Kézirat, ELTE. Budapest.
SOÓS, M. & DÓDONY, I. (1989): A TEM study of „ORTHOPYROXENE" from a lherzolite nodule. Zeitschrift für Kristallographie, Suppl. Issue No.2. 157. 12th European Crystallogr. Meeting. Abstract.
SOÓS, M., JÁNOSI, M., DÓDONY, I. & LOVAS, GY. (1991): Anomalous grandite garnet from Recsk, Mátra Mts. (N-Hungary). N. Jb. Miner. Mh., 2, 76–86.

SZABÓ, CS. (1985): Xenoliths from Cretaceous lamprophyres of Alcsútdoboz-2. borehole, Transdanubian Central Mountains, Hungary. Acta Miner. Petr., Szeged, 27, 39–51.
SZAKÁLL, S. (1989): Adatok a Mátra ásványainak ismeretéhez I. Folia Hist.-nat. Matr., 14, 9–31.
SZAKÁLL, S. (1992a): Hazai földtani képződmények új ásványai. Kézirat. Herman Ottó Múzeum, Miskolc.
SZAKÁLL, S. (1992b): Magyarország új ásványai I. Pszeudobrookit és harmotom a Mátrából. Földt. Közl., 122/2–4. 287–294.
SZAKÁLL, S. (1992c): Zeolite minerals from intermediate volcanic rocks of Tokaj Mts, NE-Hungary. Acta Miner. Petr., Szeged, 32, 25–36.
SZAKÁLL, S. & KOVÁCS, Á. (1992): Adatok a Cserhát és a Karancs-hegycsoport ásványainak ismeretéhez. Folia Hist.-nat. Matr., 17, 27–46.
SZAKÁLL, S. (1993): Axinites ásványparagenezis a Bükk hegységben. Észak-magyarországi földtani kutatások újabb eredményei. Miskolci Egyetem.
SZAKÁLL, S. & GATTER, I. (1993): Magyarországi ásványfajok. Fair-System. Miskolc. 211.
SZAKÁLL, S. & JÁNOSI, M. (1993): Taranakite from the limestone caves of Bükk Mts, NE-Hungary. Newest Results in Research, Protection and Use of Caves of Bükk Mountains. Univ. of Miskolc. 29–33.
SZAKÁLL, S. & KOVÁCS, Á. (1993): Az erdőbényei Mulató-hegy járulékos ásványai. Topogr. Mineral. Hung. I. 69–84.
SZAKÁLL, S., BIRCH, W. D., KOVÁCS, Á. & POSTL, W. (1994a): Arsenate minerals from Hungary. Acta Miner. Petr., Szeged, 35, 5–25.
SZAKÁLL, S., BOGNÁR, L. & KOVÁCS, Á. (1994b): A telkibányai érces terület szulfátásványai. Topogr. Mineral. Hung II. 233–247.
SZAKÁLL, S., DÓDONY, I. & KOVÁCS, Á. (1994c): A telkibányai érces terület halogenidjei. Topodr. Mineral. Hung. II. 253–257.
SZAKÁLL, S., FÖLDVÁRI, M. & KOVÁCS, Á. (1994d): Foszfátásványok a recski és a parád-parádfürdői ércesedésekből. Folia Hist.-nat. Matr., 19, 23–36.
SZAKÁLL, S., MOLNÁR, F., KOVÁCS, Á. & DÓDONY, I. (1994e): A telkibányai érces terület szulfidásványai. Topogr. Mineral. Hung. II. 149–181.
SZAKÁLL, S. & KOVÁCS, Á. (1994): Magyarország új ásványai II. Mimetezit és olivenit Rudabányáról. Földt. Közl., 124/4, 441–450.
SZAKÁLL, S. & KOVÁCS, Á. (1995): Silver minerals from Rudabánya. Acta Miner. Petr., Szeged, 36, 5–15.
SZAKÁLL, S., DÓDONY, I. & KOVÁCS, Á. (1995): Volfrámásványok a nagybörzsönyi ércesedésből. Folia Hist.-nat. Matr. 20, 3–12.
SZAKÁLL, S. & FÖLDVÁRI, M. (1996): Magyarország új ásványai III. Ferroaxinit és krizokolla Miskolc-Lillafüredről. Földt. Közl, 125/3–4. 433–442.
SZAKÁLL, S., FÖLDVÁRI, M., PAPP, G., KOVÁCS-PÁLFFY, P. & KOVÁCS, Á. (in press): Secondary sulphate minerals from Hungary. Acta Miner. Petr., Szeged.
SZATMÁRI, P. (1966): Az 1961–1965. évi nyugatmecseki gipszkutatás összefoglaló földtani jelentése. Kézirat. MGSZ Adattár.
SZEDERKÉNYI, T. (1962): A II. Kutatócsoport 1962. évi Jelentése a Ny. Mecsekben végzett kutatásokról. Kézirat. MÉV Adattár. Pécs.
SZENTPÉTERY, I., FÖLDVÁRI, M. & FARKAS, L. (1989): Gorceixit előfordulása Magyarországon (Szuhogy 6. sz. fúrás). Földt. Közl., 119, 89–115.
SZTRÓKAY, K. (1959): Ásványtani megfigyelések az Aggteleki cseppkőbarlangból. Földt. Közl., 89/3. 280–285.
SZTRÓKAY, K. (1986): Mullit a celli Sághegy buchitos bazaltjában. Földt. Közl., 116/4. 347–351.
SZTRÓKAY, K., TOLNAY, V. & FÖLDVÁRI-VOGL, M. (1961): A kabai meteorit. Földt. Közl., 91/2. 183–207.
TAKÁCS, J. & MOLNÁR, F. (1993): Az erdőbényei Mulató-hegy kvarc- és opálváltozatai. Topogr. Mineral. Hung I. 19–41.
TÖRÖK, K. (1993): Sillimanite-mullite transition phase in a sillimanite quartzite xenolith from the Ság-hegy basalt (Little Plain Volcanic Field, W-Hungary). Földt. Közl., 123/1, 55–67.
TÖRÖK, K. (1994): Crustal xenoliths from the Pliocene Alkaline Basalts from the Balaton Highland (W-Hungary) IMA 16th General Meeting, Pisa, Abstract, 411.
TÖRÖK, K. (1995): Garnet breakdown reaction and fluid inclusions in a garnet-clinopyroxenite xenolith from Szentbékkálla (Balaton Highland, Western Hungary). Acta Vulcanologica, 7(2), 285–290.
TÖRÖK, K. (1996): High-pressure/low temperature metamorphism of the Kő-hegy gneiss, Sopron (W-Hungary, Eastern Alps); phengite barometry and fluid inclusions. European Journal of Mineralogy, 8, 917–925.
VARGA–MÁTHÉ (1966): Beidellitesedés és biotitosodás tufára települt andezitben Mátrafüred környékén. MÁFI Évi Jel. az 1964. évről. 423–433.

VICZIÁN, I. (1993): Clay mineralogy of Middle Triassic evaporitic and carbonate rocks, Mecsek Mts.(Southern Hungary). 11th Conference on Clay Mineralogy and Petrology Č. Budejovice, 1990, Univerzita Karlova, Praha, 135–144.

VICZIÁN, I., KOZÁK, M. & SZŐŐR, GY. (1986): Markazit, copiapit és romboklász az uzsai alsó-pannóniai kavicsösszletben. MÁFI Évi Jel. az 1984. évről. 377–387.

VINCZE-SZEBERÉNYI, H. (1982): Feldspat-Megakristalle aus ungarischen Basalt. Ann. Hist.-Nat. Mus. Nat. Hung., 74, 11 –15.

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A STRUCTURAL STUDY ON SZAIBELYITE FROM ITS TYPE-LOCALITY (RÉZBÁNYA, BIHAR MTS., RUMANIA)

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ABSTRACT

Original szaibelyite $Mg_2(OH)[B_2O_4(OH)]$ material from its type-locality (Rézbánya, Bihar Mts., Rumania) has been investigated. Starting with an XPD *ab initio* determination, its unit cell was refined to the values of a=12.571(1), b=10.4025(9), c=3.1333(4) Å and β=95°54.2(9)' in $P2_1/a$ symmetry. The crystal structure was refined by Rietveld method on the basis of TAKÉUCHI'S (1973) model. The results converged to an atomic arrangement similar to the one determined for a szaibelyite sample from Königshall-Hindenburg, Germany. A search to find traces of an orthorhombic polytype in the XPD pattern, due to the 2_1 pseudosymmetry, failed to identify any. Neither was successful the attempt to find significant differences between the szaibelyite and a sample called 'ascharite' from Stassfurt. TEM investigations revealed, that the [001] elongated crystallites of szaibelyite occur in bundles in which the individual fibres are randomly oriented around their c axis. Its most characteristic real structural feature is the (100) twinning producing weak diffuse scattering parallel to the a* axis in the SAED patterns. No polytype modifications or periodic twinning of the basic crystal structure were observed in the material. These results confirm the priority of the original description of szaibelyite (PETERS, 1861). In spite of the low accuracy of the early chemical analysis, the original description proved to be valid and in good accordance with the recent results.

KEYWORDS: szaibelyite, type-locality, structure, XPD, real structure, TEM

INTRODUCTION

In the course of a systematic reinvestigation of several Hungary-related minerals the study of szaibelyite was undertaken. The type specimen of this mineral (PAPP & WEISZBURG, 1991) was first described by PETERS (1861) and has remained poorly characterised ever since due to its relative complex paragenesis. The title material occurs in massive contact marble in the form of radial aggregates of fine bundles of asbestiform (Fig. 1) crystallites in intimate coexistence with other boron bearing Mg-minerals like kotoite and fluoborite. The lack of up-to-date descriptive data of szaibelyite has raised recently some confusion between this mineral and an other one called ascharite (FEIT, 1891) which gives a special actuality to the present work.

EXPERIMENTAL DETAILS

A tedious preparatory process consisting of dilute acid treatment, repeated sedimentation and hardness selective separation resulted in a practically monomineralic

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szaibelyite sample, that was suitable for further study. The X-ray powder diffraction (XPD) data collection was carried out using CuK_α-radiation (λ=0.154178 nm) on a Siemens D5000 powder diffractometer with theta-theta Bragg-Brentano geometry, fixed slits and a pyrolitic graphite secondary monochromator. The measurement control and all subsequent calculations were performed using the integrated computing facilities of the D5000 system. The intensity data were collected with the step-scan technique in the 5.00-79.00°2ϑ angular range using a step width of 0.02°2ϑ. The *ab initio* indexing of the powder pattern and unit cell determination was carried out using the ITO program of VISSER (1969) and the unit cell parameters were refined by a local version of the UNITCELL program (APPLEMAN & EVANS, 1973, The Rietveld analysis was performed by means of the GSAS program package of LARSON & VONDREELE (1987).

The dilute acide etched szaibelyite-containing marble surface was imaged under a HITACHI S2360N type, low vacuum scanning microscope attached with a Robinson detector.

Electron transparent samples were prepared by argon ion milling and suspension techniques. Selected szaibelyite bundles were crushed under ethanol, and drops of the suspension were allowed to dry on holey-carbon TEM grids. TEM images and SAED patterns were obtained at 100 kV under a JEOL 100CX electron microscope equipped with a a tilt (± 60°) – rotate (± 360°) goniometer stage. The electron micrographs of oriented crystals and their SAED patterns were obtained at optimum conditions using an objective aperture with a radius of 4.5Å^{-1} in the diffraction plane. The intensive radiation damage of szaibelyite limited the usable illumination time and/or brightness making the high resolution imaging especially difficult. The processing of digitised micrographs were performed on a Macintosh computer using Adobe Photoshop 3.0 software. The HRTEM image simulations and related calculations were done using the MSI Cerius^2 program package on an SGI workstation.

POWDER DIFFRACTION RESULTS

Following the data reduction, an *ab initio* unit cell determination was attempted using the zone indexing method.The first 30 reflections (with the lowest scattering angles) were included in the calculation and all symmetries lower than tetragonal were taken into consideration. The resulting four solutions were all monoclinic and the unit cell (a=12.556, b=10.383, c=3.129 Å, β=95.96°) with the highest DEWOLF (1968) figure of merit (M_{20}=24) indexed all of the starting reflections.The reflection set, calculated from this unit cell supposing a primitive lattice and no translation symmetry, was corroborated with the observed powder data in order to find systematic absences.The absence of 010, 030, 100, 300, –101 and 101 reflections in the low angle zone is in good agreement with the $P2_1/a$ symmetry determined by TAKÉUCHI & KUDOH (1975) for a szaibelyite sample from Königshall-Hindenburg, Germany. Subsequently the whole observed powder data set was indexed with this unit cell in $P2_1/a$ symmetry and the cell parameters were refined. The refinement converged to the values of a=12.571(1), b=10.4025(9), c=3.1333(4) Å and β=95°54.2(9)'.The Figures of Merit F_{20}=38(.017,32) and M_{20}=26 show the reliability of the indexing all of the 60 suitably resolved reflections (Table 1). The 2.745 g/cm^3 calculated density and its observed value of 2.66 g/cm^3 are well within the range of 2.60–2.76 g/cm^3 reported by SCHALLER (1942) for naturally occurring $MgHBO_3$. The crystallographic data are summarized in Table 2.

X-ray powder data of szaibelyite, Rézbánya (Bihar Mts., Rumania)

h	k	ℓ	I/I_0	d_{calc}	d_{obs}	$2\vartheta_{calc}$	$2\vartheta_{obs}$	$\Delta 2\vartheta$	F_n (mean$\Delta 2\vartheta$ N_{poss})
−1	1	0	6	7.9969	7.9750	11.063	11.094	−.030	F_1= 33(.030, 1)
2	0	0	100	6.2519	6.2430	14.165	14.186	−.020	F_2= 39(.025, 2)
0	2	0	40	5.2012	5.1945	17.046	17.069	−.022	F_3= 31(.024, 4)
−1	2	0	5	4.8023	4.7952	18.474	18.502	−.027	F_4= 32(.025, 5)
−2	2	0	8	3.9984	3.9959	22.232	22.246	−.013	F_5= 36(.023, 6)
−3	1	0	17	3.8689	3.8645	22.986	23.013	−.026	F_6= 36(.024, 7)
−1	3	0	13	3.3414	3.3395	26.677	26.693	−.015	F_7= 39(.022, 8)
−3	2	0	51	3.2525	3.2506	27.420	27.437	−.016	F_8= 41(.022, 9)
0	0	1	7	3.1146	3.1184	28.659	28.624	.035	F_9= 35(.023, 11)
−2	3	0	44	3.0323	3.0313	29.455	29.465	−.009	F_{10}= 38(.022, 12)
0	1	1	23	2.9838	2.9849	29.945	29.934	.011	F_{11}= 38(.021, 14)
1	1	1	6	2.8398	2.8389	31.501	31.512	−.010	F_{12}= 35(.020, 17)
−2	1	1	10	2.8023	2.8016	31.934	31.943	−.008	F_{13}= 38(.019, 18)
−3	3	0	88	2.6656	2.6648	33.619	33.630	−.010	F_{14}= 34(.018, 22)
2	1	1	22	2.5952	2.5960	34.559	34.549	.010	F_{15}= 33(.018, 25)
1	2	1	20	2.5673	2.5657	34.947	34.970	−.022	F_{16}= 34(.018, 26)
−2	2	1	44	2.5394	2.5402	35.343	35.333	.010	F_{17}= 33(.018, 29)
−5	1	0	72	2.4315	2.4313	36.968	36.971	−.002	F_{18}= 36(.017, 30)
−2	4	0	13	2.4011	2.4000	37.452	37.470	−.017	F_{19}= 36(.017, 31)
2	2	1	18	2.3823	2.3816	37.759	37.771	−.011	***F_{20}= 38(.017, 32), M_{20}=26***
−3	2	1	9	2.3455	2.3447	38.374	38.389	−.014	F_{21}= 38(.017, 33)
0	3	1	44	2.3171	2.3171	38.864	38.864	.000	F_{22}= 38(.016, 37)
−4	1	1	7	2.2731	2.2741	39.647	39.630	.017	F_{23}= 37(.016, 39)
−3	4	0	82	2.2063	2.2070	40.900	40.887	.013	F_{24}= 35(.016, 43)
3	2	1	8	2.1644	2.1646	41.729	41.726	.003	F_{25}= 37(.015, 44)
2	3	1	7	2.1204	2.1220	42.635	42.603	.032	F_{26}= 35(.016, 46)
6	0	0	76	2.0839	2.0846	43.420	43.406	.014	F_{27}= 35(.016, 49)
−1	5	0	8	2.0522	2.0535	44.125	44.098	.027	F_{28}= 34(.016, 51)
−5	3	0	12	2.0283	2.0282	44.675	44.676	−.000	F_{29}= 35(.016, 53)
0	4	1	30	1.9962	1.9958	45.432	45.442	−.009	***F_{30}= 34(.016, 56)***
−2	5	0	16	1.9740	1.9743	45.972	45.965	.007	F_{31}= 35(.015, 58)
−6	2	0	14	1.9344	1.9351	46.968	46.952	.016	F_{32}= 33(.015, 63)
−5	2	1	8	1.9120	1.9144	47.553	47.490	.063	F_{33}= 30(.017, 65)
−6	1	1	14	1.7935	1.7934	50.869	50.870	−.000	F_{34}= 29(.016, 73)
−7	1	0	12	1.7605	1.7601	51.893	51.906	−.012	F_{35}= 28(.016, 76)
0	5	1	24	1.7300	1.7298	52.876	52.882	−.005	F_{36}= 28(.016, 82)
−2	5	1	17	1.6924	1.6919	54.146	54.162	−.015	F_{37}= 27(.016, 87)
2	5	1	9	1.6434	1.6427	55.900	55.927	−.026	F_{38}= 26(.016, 91)
−6	3	1	17	1.6120	1.6115	57.087	57.108	−.020	F_{39}= 24(.016, 98)
−5	5	0	13	1.5993	1.5991	57.581	57.589	−.007	F_{40}= 25(.016,101)
−7	3	0	7	1.5879	1.5878	58.034	58.041	−.006	F_{41}= 25(.016,102)
8	0	0	10	1.5629	1.5623	59.052	59.078	−.025	F_{42}= 25(.016,105)
0	0	2	14	1.5573	1.5569	59.288	59.303	−.014	F_{43}= 25(.016,106)
−2	0	2	11	1.5490	1.5489	59.639	59.644	−.004	F_{44}= 26(.016,109)
5	4	1	21	1.5122	1.5125	61.240	61.227	.013	F_{45}= 24(.016,117)
1	6	1	20	1.4949	1.4952	62.027	62.017	.010	F_{46}= 24(.016,121)
−1	7	0	15	1.4756	1.4756	62.930	62.930	.000	F_{47}= 24(.015,130)
−6	5	0	10	1.4723	1.4721	63.088	63.101	−.012	F_{48}= 24(.015,132)
−8	3	0	7	1.4249	1.4250	65.445	65.437	.008	F_{49}= 22(.015,148)
−3	7	0	8	1.3997	1.3998	66.774	66.767	.007	F_{50}= 21(.015,156)
−7	4	1	9	1.3770	1.3773	68.025	68.010	.015	F_{51}= 21(.015,163)
−7	5	0	6	1.3552	1.3549	69.271	69.288	−.016	F_{52}= 20(.015,170)
0	7	1	10	1.3412	1.3406	70.102	70.140	−.037	F_{53}= 19(.015,178)
−6	6	0	8	1.3328	1.3332	70.610	70.587	.023	F_{54}= 19(.016,184)
0	8	0	6	1.3003	1.3005	72.651	72.640	.011	F_{55}= 18(.015,197)
−9	3	0	6	1.2896	1.2904	73.349	73.300	.049	F_{56}= 17(.016,204)
10	0	0	6	1.2503	1.2505	76.053	76.046	.007	F_{57}= 16(.016,222)
−3	8	0	10	1.2413	1.2415	76.710	76.690	.020	F_{58}= 16(.016,228)
−9	4	0	6	1.2254	1.2257	77.891	77.870	.021	F_{59}= 15(.016,236)
−3	5	2	4	1.224	1.2226	78.119	78.098	.021	F_{60}= 16(.016,238)

TABLE 2

Crystal data for szaibelyite, Rézbánya (Bihar Mts., Rumania)

Formula	$Mg_2(OH)[B_2O_4(OH)]$
Crystal system	monoclinic
Space group	$P2_1/a$ (14)
a (Å)	12.571(1)
b (Å)	10.4025(9)
c (Å)	3.1313(4)
β (°)	95 54.2(9)
V (Å^3)	407.30(6)
Z	4
$\mathbf{d_c}$(g/cm^3)	2.745
$\mathbf{F_{30}}$ (SMITH & SNYDER, 1979)	34(0.016,56)
$\mathbf{M_{20}}$ (DE WOLFF, 1968)	26

TABLE 3

Refined atomic positions of szaibelyite, Rézbánya (Bihar Mts., Rumania)

Atom	x/a	y/b	z/c	U_i*100	s.o.f.
Mg(1)	.5052(1)	.1378(1)	.2311(6)	5.13(15)	1.0
Mg(2)	.4113(1)	.4185(1)	.7098(5)	4.66(16)	1.0
B(1)	.1427(2)	.1759(2)	.7372(13)	1.80(18)	1.0
B(2)	.3008(2)	.0464(2)	.5787(13)	1.81(17)	1.0
O(1)	.0836(2)	.0611(2)	.8014(9)	1.21(17)	1.0
O(2)	.0997(1)	.2933(1)	.8149(8)	3.14(17)	1.0
O(3)	.2534(1)	.1626(2)	.7304(8)	3.49(17)	1.0
O(4)	.2468(1)	.4411(1)	.6124(9)	2.64(18)	1.0
O(5)	.4071(1)	.0417(2)	.7448(8)	3.60(17)	1.0
O(6)	.4034(1)	.2930(1)	.1928(8)	1.73(16)	1.0

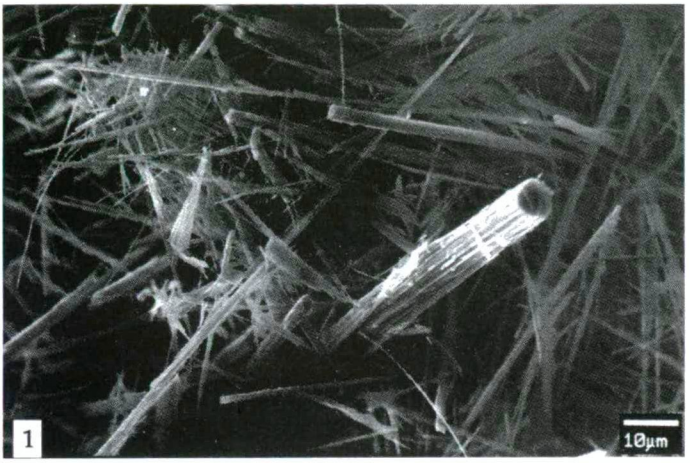

Fig. 1. SEM image of the etched surface of marble containing the szaibelyite material

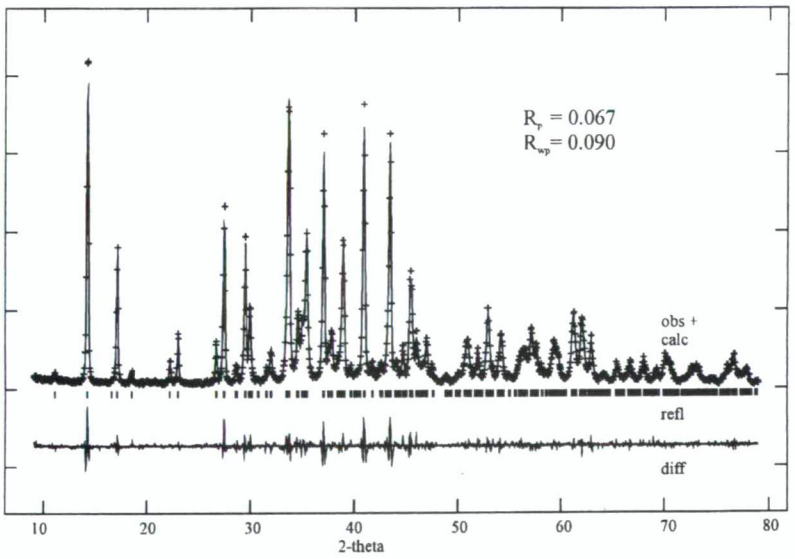

Fig. 2. Observed and calculated powder profile of szaibelyite (Rézbánya)

A Rietveld analysis of the powder pattern of szaibelyite was also undertaken. Starting with the monoclinic structural model of TAKÉUCHI & KUDOH (1975), the refinement converged to the R factors of R_p=0.067, R_{wp}=0.090 in spite of the difficult-to-handle fibrous (Fig. 1) preferred orientation. The observed (crosses) and calculated (continuous line) powder profile together with their difference plot and marks of the Bragg positions are shown in Fig. 2. The final atomic parameters can be seen in Table 3. A perspectivic view of the szaibelyite structure along the c-axis is shown in Fig. 3. The octahedra

represent MgO_6 groups, the BO_3 units are drawn as trigons and the size and orientation of the unit cell is also marked.

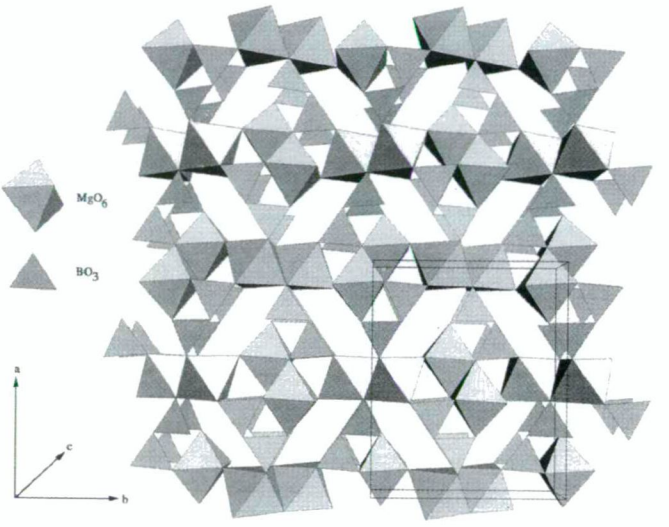

Fig. 3. The crystal structure of szaibelyite

TRANSMISSION ELECTERON MICROSCOPIC RESULTS

The cross section of a szaibelyite bundle is shown in Fig. 4. The crystallites are oriented to each other subparallelly with their c axis. The grains boundaries are irregular and the grains are separated by narrow band of noncrystalline material. The SAED pattern of the area shown in Fig. 4 is a powder pattern like one (Fig. 5) that proves the absence of distinct orientation relationship between the crystallites in nearly common [001] projection.

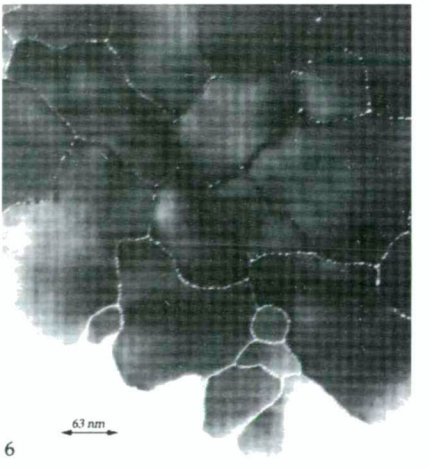

Fig. 4. TEM micrograph of a szaibelyite bundle in cross section

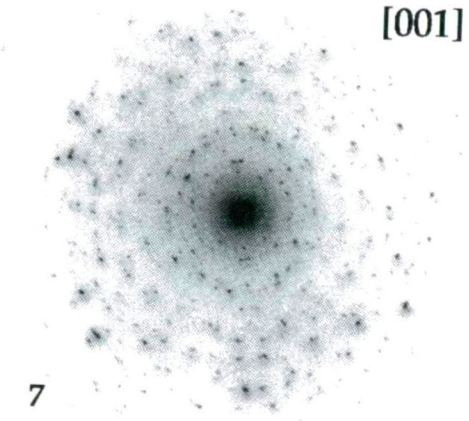

Fig. 5. SAED pattern of the area shown in Fig. 4

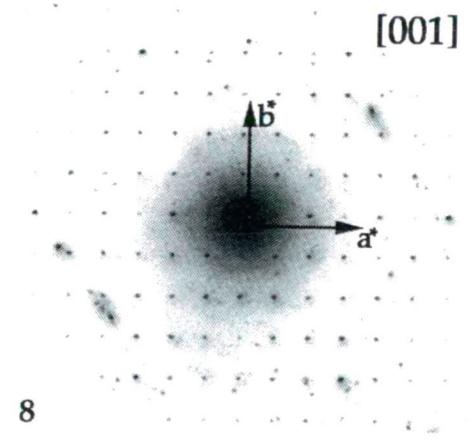

Fig. 6. SAED pattern of a szaibelyite crystall in [001] projection

The SAED pattern of a [001] projected crystal (Fig. 6) reveals the ideal crystal structure of the grain boxed in Fig. 7. The enhanced and Fourier filtered image of this crystal (Fig. 8) corresponds well to the simulated high resolution electron microscopic image (inserted) calculated on the basis of the final Rietveld refinement results. The undulating brightness in the images is caused by the different thickness of the sample.

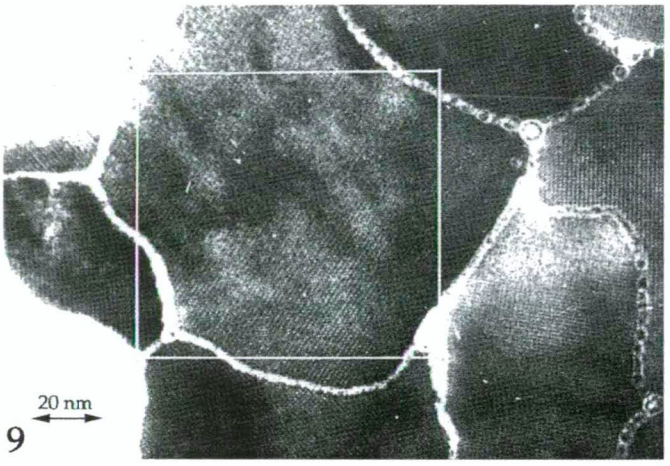

Fig. 7. Fiber axis projected high resolution micrograph of szaibelyite grains

The structure of szaibelyite crystallites in [*uw*0] orientations were studied on samples prepared by suspension technique. Some of the grains show in [010] projection aperiodic twin structure (Fig. 9). The twin and the composition plane is the (100). The Fig. 9a is a bright field, while the Fig. 9c is a dark field image illuminated with the direct beam and the *002* reflection of one set of the twin system respectively.

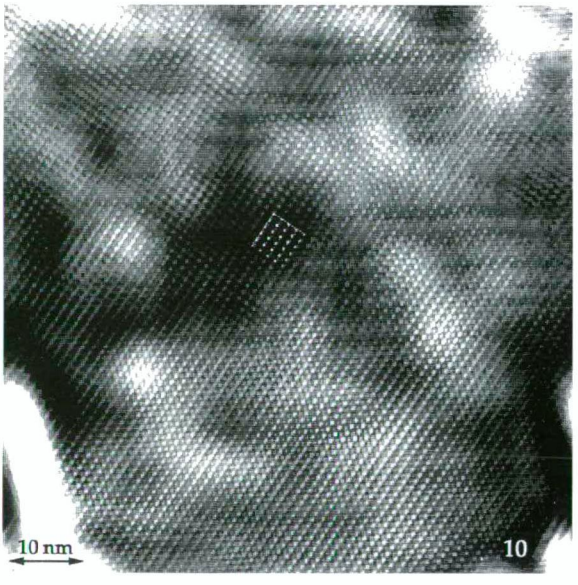

Fig. 8. Fourier filtered reconstruction of the boxed area in Fig. 7. The corresponding simulated HRTEM image is inserted in the middle

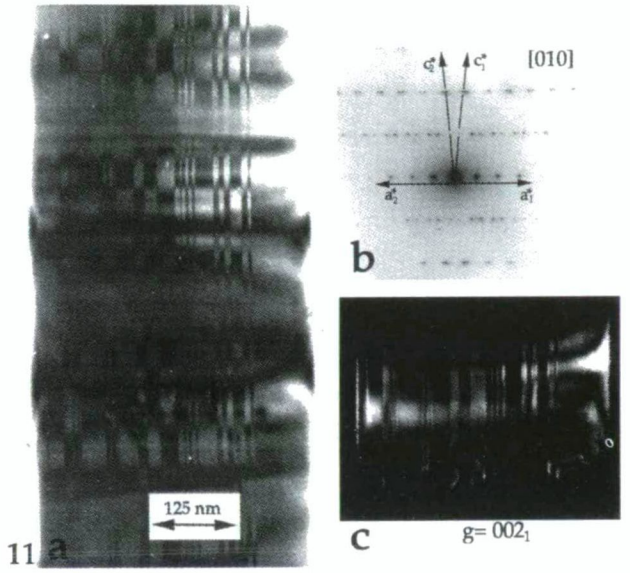

Fig. 9. Twinned szaibelyite fiber in [010] projection. **a**: Bright field image; **b**: The SAED pattern of the grain; **c**: Dark field micrograph imaged with one of the *002* reflections

DISCUSSION

The *ab initio* X-ray powder diffraction unit cell determination and the Rietveld refinement results prove, that the crystal structure of the szaibelyite from Rézbánya is monoclinic ($P2_1/a$ (14)) and has the same atomic arrangement as determined for a szaibelyite sample from Königshall-Hindenburg, Germany by TAKÉUCHI & KUDOH, (1975). The structure (Fig. 3) is built up of c-axis directed chains of edge sharing double octahedra of MgO_6. These chains sharing corners form a sheet parallel to (100). Double triangular pyroborate ions $[B_2O_4(OH)]^{3-}$ are the links between the sheets. Along the chain of inversion related octahedra a strong 2_1 pseudosymmetry can also be recognized. Since on the basis of combination of the original- and pseudo symmetries various polysynthetic twins could be theorethically derived, the XPD observations were checked for indications of the presence of resulting polymorphic variations. The powder pattern of the characteristic non-monoclinic polytype ($P2_12_12_1$, a=12.511, b=10.393, c=3.139Å, TAKÉUCHI & KUDOH, (1975)) was calculated and compared to the profile of szaibelyite from Rézbánya (Fig. 10), but no significant coincidences were found. The observed powder profile of szaibelyite from its type-locality was also corroborated with the one of another sample called 'ascharite' from Stassfurt (Fig. 11) and no characteristic difference (except for some minor textural effects due to the fibrous habit) was found between them.

The TEM investigations revealed, that the [001] elongated crystallites of szaibelyite occur in bundles in which the individual fibres are randomly oriented around their c axis. The mean size of the crystals is in the 100 nm range in cross section and the most common faces observed are (100) and (010). The most characteristic real structural feature of the title material is the (100) twinning producing weak diffuse scattering parallel to the a* axis

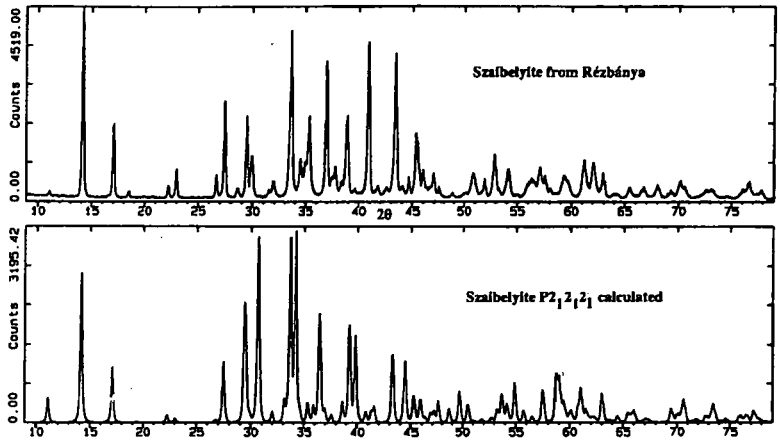

Fig. 10. Comparison of the powder profiles of szaibelyite from Rézbánya and that of its theoretical orthorombic polytype

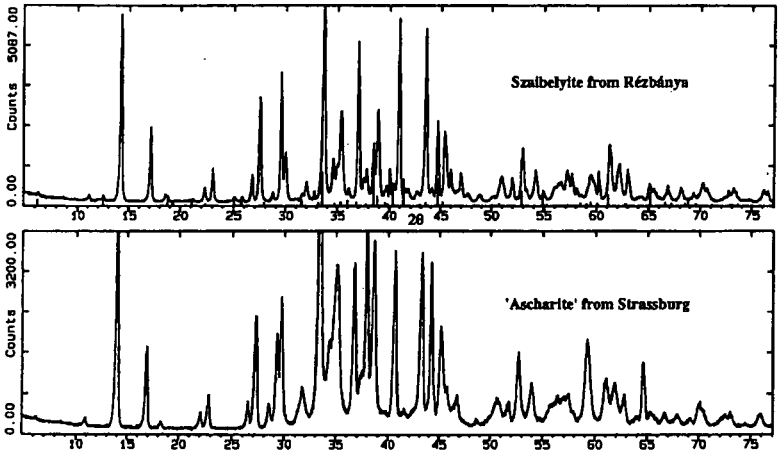

Fig. 11. Comparison of the powder patterns of szaibelyite from Rézbánya and that of „ascharite" from Stassfurt

in the selected area electron diffraction patterns. This phenomenon may explain the line broadening observed in the high angle region of the powder pattern. The thickness of the twin lamellae is a few nm. No polytype modifications or periodic twinning of the basic crystal structure were observed.

The results of the above structural measurements made on the material of the type locality confirm the priority of the original description of szaibelyite by PETERS (1861). In spite of the low accuracy of the early chemical analysis, the original description proved to be valid and in good accordance with the recent results.

ACKNOWLEDGEMENT

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REFERENCES

APPLEMAN, D.E., EVANS, H.T. JR. (1973): Job 9214: Indexing and least-squares refinement of powder diffraction data. Report PB2-16188, U.S. Dept. of Commerce, National Technical Information Service

FEIT, W. (1891): Über Ascharit, ein neues Borsäure-Mineral, Chem.-Ztg. **15**, 327

LARSON, A.C., VON DREELE, R.B. (1987): GSAS-Generalized Structure Analysis System, Los Alamos National Laboratory Report **No. LA-UR-86-748.**

PAPP, G., WEISZBURG, T. (1991): The history of the Mineral and Rock Collections of the Eötvös Loránd University, Budapest. Annals of the History of Hungarian Geology, MFT. Budapest. Spec. Issue (3) for the 16th Internat. Symp. of INHIGEO. pp. 115–133.

PETERS, K.F. (1861): Geologische und mineralogische Studien aus dem südöstlichen Ungarn, inbesondere aus der Umgegend von Rézbánya 2. Teil. S.-B. Akad. Wiss. Wien,**44**, 81–155

SCHALLER, W.T. (1942): The identity of ascharite, camsellite and β-ascharite with szaibelyite and some other relations of the magnesium borate minerals. Am. Mineral. **27**, 467–481.

SMITH, G.S., SNYDER, R.L. (1979): A criterion for rating powder diffraction patterns and evaluating the reliability of powder-pattern indexing. J.Appl.Crystallogr.,**12**, 60.

TAKÉUCHI, Y., KUDOH, Y. (1975): Szaibelyite, $Mg_2(OH)[B_2O_4(OH)]$: crystal structure, pseudosymmetry, and polytypism. Am.Min.,**60**, 273–279

VISSER, J.V., (1969); A fully automatic program for finding the unit cell from powder data, J. Appl. Cryst.,**2**, 89–95.

DEWOLFF, P.M. (1968). A simplified criterion for the reliability of a powder pattern indexing. J.Appl. Crystallogr.,**1**, 108

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RESULTS OF MINERAL EXPLORATION IN KÁRPÁTALJA (CARPATHIAN UKRAINE) REGION

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Department of Carpathian Ukraine of Ukrainian Information Centre

INTRODUCTION

All geological investigations which are in connection with ores, minerals and other geological-type row-materials have been carried out by the Kárpátalja (Carpathian Ukraine) Geological Prospecting Company. It was founded 31. May 1950 and its centre was pointed out in Visk locality and in 1954 year it was removed to Beregovo (Beregszász). This town has given the centre until today. Expences of the reserach activity had been produced from the budget in 90% rate until 1994 year.

Main tasks of this company are as follows: geological mapping and all geological-geophysical works which are necessary for the recovery of row materials for the mining industry. I. g. apart from the detailed geological mapping (12.800 km^2 area) more than 60 km.s long gangway, 15 km prospecting shafts, 700.000 m^3 trenches, 10.000.000 m.s long boreholes were realized during 45 years period.

MAIN RESULTS OF THE PROSPECTING

I. *Ore fields*

1. *Beregovo (Beregszász) district:* Muzsijevo (Muzsa) and Beregovo (Beregszász) and Kavaso hydrothermal gold and polymetallic mineralization as well as related kaolinite and alunite accumulation (Muzsijevo and Kavaso); perlite (Senay, Varna and Ardo); several smaller ore and non metallic occurrences.
2. *Rachow (Rahó) district:* Sauiak gold and Rachow hydrothermal polymetallic and gold mineralizations and numerous smaller occurrences as well as Talabor and Solotina (Aknaszlatina) huge salt accumulations.
3. *Begany district:* with hydrothermal alunite-barite-gold polymetallic ore deposits at Begany and germanium-rich brown-coal beds and numerous smaller ore and non-ore indications.
4. *Visk district:* mercury accumulations at Saian and Grendes localities and zeolite at Seklence as well as numerous smaller ore and non-ore indications.
5. *Peretscheni (Perecsényi) district:* mercury deposits at Dubrinec (Dubrincs) and Olenova localities; kaoline at Dubrinec (Dubrincs) and numerous smaller metallic and non-metallic accumulations.

II. *Numbers of explored occurrences*

Gold and silver	6
Polymetallic accumulations	5
Mercury	6
Brown coal	8
Salt	2
Barite	1
Kaoline	2
Zeolite	1
Bentonite	2
Coloured earths	2
Limestone	4
Dolomite	2
Marble	10
Andesite	22
Brick-clay	38
Keramsite	1
Perlite	4
Sand and gravel	14
Drinking water	17
Thermal water	4
Mineral water	16
Altogether	167

III. *Factories, companies for the utilization of mineral resources of Carpathian Ukraine (Kárpátalja)*

Kárpátalja Gold-Polymetallic Combinate	
Királyháza Chemical Industry	
Borzsava Calcine Works	
Brick factories	28
Ceramic factories	8
Rachow and Királyvölgy Marble Quarries	
Huszt Stone Cutter Works Quarries	12
Sand and gravel pits	10
Mineral water bottler factories	8
Spa	1
Sanitaria	9
Water-works	7
Artesian wells	697

IV. *Metallogenic map of NE Carpathians*

Fig. 1. shows a metallogenic sketch referring to the area of Carpathian Ukraine (Kárpátalja) and adjacent Slovakian, Hungarian and Romanian border zones.

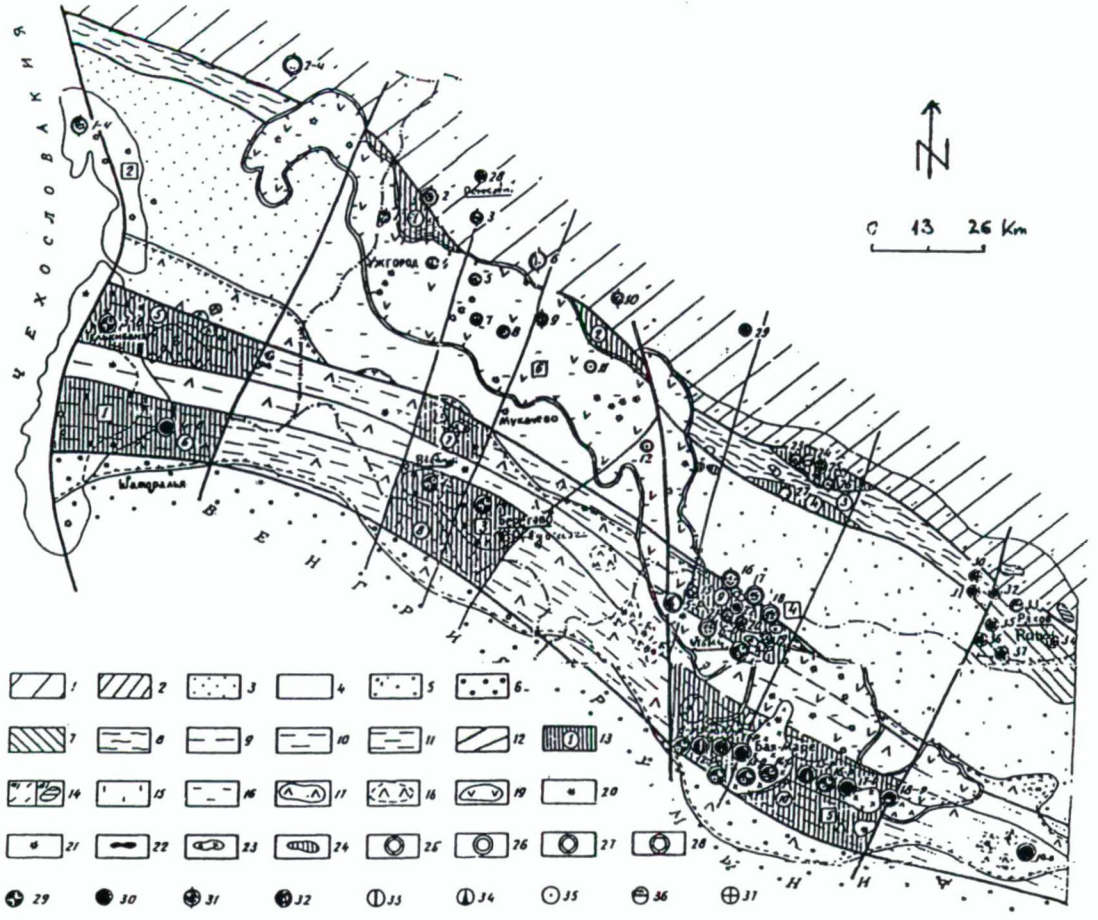

Fig. 1. Metallogenic sketch of NE Carpathians (V. N. ZAJCEVA 1971)

LEGEND: *Structural zoning:* 1–2. Geosynclinal area of Carpathians (1 = miogeosyncline, 2 = Inner Carpathian geosynclinal subzone with spilite-keratophyric volcanism). 3–5 Sub-Carpathian inner folded and fractured zone (3 = East Slovakian, 4 = Csop-Mukacseve, 5 = Solotvinsk, 6 = Hungarian, 7 = Maramures Massif). 8–11 Deep-fractures (8 = Sub-Carpathian, 9 = Old Pannonian fractures, 10 = Dobrony-Visk, 11 = Beregove-Baia Mare) 12. lower degree fractures. 13. uplifts of Pre-Neogene basement. Numbers are marked with circles, as follows: ① Peretscheni, ② Szvaljava, ③ Ugljansk, ④ Pragov, ⑤ Vilyvitány, ⑥ Sátoraljaújhely, ⑦ Dobrony, ⑧ Beregovo, ⑨ Visk, ⑩ Baia Mare.

Structural stages and levels: 14. Elements of Alpine Geosyncline (14a = Cretaceous-Paleogene flysch, 14b = Cretaceous volcanics, miogeosynclinal spilite-keratophyric association with Neogene reactivation). 15. Miocene tuffaceous molasse, so-called „Lower structural zone". 16 = Pliocene tuffaceous molasse, so-called „Upper structural zone".

Magmatic formations. 17= Miocene (from Badenian up to Pliocene) andesite formation. 18= Ditto, in covered position (earlier magma-tectonic cycle), 20–21= Eruption centres (20 = Miocene, 21 = Pliocene), 22–24. Intrusions (22 = Cretaceous-Paleogene, 23 = Miocene, 24 = Pliocene), 25–28= Ore deposits (25 = Pliocene mercury and rare-metall enrichments, 26 = Miocene gold-bearing polymetallic ores, 27 = Cretaceous-Paleogene copper and nickel ores).

Ore fields and occurrences. 29. Polymetallic gold-bearing, 30. Polymetallic, 31. Mercury, 32. Arsenic, 33. Antimony, 34. Tellur and bismuth, 35. Molibdene, 36. Copper, 37. Cobalt-nickel, 38. Iron-manganese. *Delimitation of metallogenic fields:* 39. boundaries of mercury and rare-element occurrences, 40. boundaries of gold-bearing, polymetallic ores.

Volcanic masses: (in quadratic frames) 1 Tokaj, 2 Presov, 3 Beregove, 4 Visk, 5 Baia Mare, 6 Vihorlat-Gutin.

Ore fields in Slovakia: 1–4. Dubnik (Hg), 2–4. Mernik (Hg). *Fields in Hungary:* 3-B. Telkibánya (Au), 4-B. Sátoraljaújhely (Pb, Zn). *Fields in Romania:* 5-p. Tarna Mare (Pb, Zn, Au), 6-p. Komirzan (Hg, Au), 7-p. Biksad (Au, Ag, Hg), 8-p. Raksa (Au, Ag), 9-p. Nistru (Pb, Zn), 10-p. Ilba (Pb, Zn), 11-p. Beica (Cu, Pb, Zn), 12-p. Sesar (Au, Ag), 13-p. Higis (Au, Ag), 14-p. Gilau-Kuci (Au, Ag), 15-p. Baie Sprie (Pb, Zn, Cu, Au), 16-p. Suior (Au, Ag, Pb, Zn, Cu), 17-p. Cavnic (Pb, Cu, Zn, Au), 18-p. Beiuc (Pb, Cu, Zn, Au), 19-p. Cibles (Cu, Pb, Zn). *Fields in Carpathian Ukraine:* 1. Csontos (Hg), 2. Dubrinic (Hg), 3. Turica (Hg), 4. Antalovci (Hg, Te), 5. Lockanevo (Hg, Te, Mo), 6. Olenovo (Hg), 7. Podulki (Te, Bi, Hg, Mo), 8. Viznica (Hg, Te, Mo), 9. Sinjak (Hg), 10. Poiana (Hg), 11. Dehmanov (Te, Bi, Mo), 12. Sholles (Te, Bi, Mo, Cu), 13. Begany (Ba, Zn, Pb, Au, Ag), 14. Beregovsk (Zn, Pb, Au, Ag), 13–14. Miocene origin, 15. Zagodotschnoe (Hg), 16. Beregsurany (Hg), 17. Grendes (Hg, Pb, Zn), 18. Borkut (Hg), 19. Marangosh (Hg), 20. Povorotnoe (Hg), 21. Rovnoe (Hg, Pb, Zn), 22. Bania (Pb, Zn Miocene origin), 23. Monostor (Hg), 24. Aldermirov (Cu), 25. Kamennoe (Ni, Cr), 26. Luzsanskoe (Hg), 27. Dragovszkoe (Hg, As), 28. Tschernogolovo (As), 29. Soimü (Sb, As), 30. Koobclecki Poliana (Pb, Zn), 31. Kamen-Klevka (Pb, Zn), 32. Glimea (Mn), 33. Krasno Pleso (Cu), 34. Berlebashka (Cu, Au), 35. Sauliak (Au), 36. Banskoe I (Au), 37. Banskoe II (Au).

⓪ Ore deposits (numbers being next to the double circles mean the above-mentioned localities)

In the present difficult economic situation the Central Fund is able to cover the research expences in 20% ratio, only. Therefore, predominant part of the objects momentarily are stopped. Due to the newest governmental regulations, the prospecting and exploitation are legitimated for foreign capitals by concession buying.

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THE MAIN GENETIC TYPES OF SPHERULES OCCURING IN THE ROCKS OF HUNGARY

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ABSTRACT

Four types of spherules obtainable from the sediments and deposits in Hungary are discernible by means of SEM and EDAX study of their chemical composition, textural structure and morphogenetics. Of *extraterrestrial origin* and of size 100–200 micron are the following: **Glassy microtektites** (Si), the **micro magnetospherules** (Fe) and the **micro siderospherules** (Si+Fe); on the other hand of *terrestrial origin* and size 200–400 micron are **the magnetopearls** (Fe).

The extraterrestric spherules show all the signs of their origin: as the cold meteorites abruptly were heated up in the Earth's atmosphere and then burst up disintegrating into their elements forming blenddrops rich in gases, and slowly cooling down while rotating with high velocity.

The tektites of different ages (Triassic, Cretaceous, Miocene) are to be found abundantly in thin clay layers of the deposits. The white and light yellow transparent tektites with low density contain small crystallites while the honey-yellow tektites of high density contain after anorthite oldhamit pseudomorphoses. Both types have blendclothfibres on their surface. The glassy tektites of different ages elements and to their proportions are completely similar to the anorthosite of the Moon's crust. All these facts prove that the material of the glassy tektites comes from the Moon's crust anorthosite minerals by escaping from there during impacts of meteorites and heated up and disintegrated into micro compound droplets when arriving into the Earth's atmosphere. The abundance of tektites in the different layers signals the ages of some big meteorite crashes on the Moon's surface.

The morphogenetics of terrestrial magnetopearls signal the process of slow and uniform crystallisation at low temperature.

The spherules, which were studied with SEM and EDAX methods are from Triassic, Miocene, Pannonian sediments and placers of Hungary.

The geological setting of these spherule deposits were presented by L. DOSZTÁLY (Budapest, Sopron), E. KROLOPP (Arak) and GY. GYURICA (Maros river mouth).

The studied spherules can be divided into 4 types according to their chemical composition, fabric and genetic features (PLATE I).

1.	Glassy microtektites	(Si)	Triassic, Miocene	extraterrestrial
2.	Micro magnetospherules	(Fe)	placer	extraterrestrial
3.	Micro siderospherules	(Fe+Si)	placer	extraterrestrial
4.	Terrestric micro magnetopearls	(Fe)	Pannonian	terrestrial

1. The **glassy microtektites** are from the thin grey clay interlayers of the Triassic limestone in Budapest at 104–120 m depth, respectively and from the Miocene clay

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sediments of Sopron at 35–40 m. The 1 cm thick grey clay interlayer in the Triassic limestone contains drop and sphere shaped microtektites of 100–200 micron size and is a honey yellow colour. They have small bubble craters on their surface and bubbles inside. Their material is rich in Si and Ca and contains also Mg, Al, K and Ba in minor amounts blend (PLATE II). The magnification by several thousand times shows drops of soft and bubbling blend material. On their surface blendfibres are visible which were impacted into the soft drops or spun on their surface (PLATE III). The blendclothfibres on the spherules derive from the disintegrated material of the meteorite by forming crystallite plates of pseudohexagonal shape (PLATE IV). The fluidal texture of the drops with the crystallites immersed shows the direction of intense rotation of their crystals and fibres, indicating also the presence of considerable physical and chemical forces involved in their formation.

The drops differ by their densities. The drops of lower density are colourless or light yellow and contain only nuclei of crystallites (PLATE III). The drops of higher density are of dark honey yellow colour; prismatic crystals of hexagonal cross section are immersed along with other crystals in the state of growing (PLATE V). The well-developed prismatic, isometric crystals of platy shape according to (001) are similar to a Ca-rich feldspar. Their CaS content, however, alludes to the meteorite mineral oldhamite. Supposedly, they are pseudomorphs of oldhamite after Ca-rich feldspar, anorthite (PLATE VI). The more exact study is made difficult by their small size; 1.5 micron diameter and 3 micron length. The chemical composition of glassy tektites is very similar to that of the anorthositic crust of the Moon's surface both as to the elements occurring and also their percentages (TABLE 1), (MAYER 1987).

TABLE 1

Weight %	Lunar soil	Anorthosite	Glassy Tektite	
		60025	Triassic	Miocene
SiO_2	45.20	43.90	44.43	39.39
CaO	15.30	18.90	34.20	37.62
Al_2O_3	26.60	35.20	9.59	9.38
MgO	6.30	0.27	7.21	9.20
TiO_2	0.58	0.02	—	—
BaO	—	—	2.45	2.80
K_2O	0.11	0.03	0.95	0.80
MnO	0.07	0.03	0.63	0.71
FeO	5.50	0.67	0.54	0.10
Cr_2O_3	—	0.04	—	—
Na_2O	0.47	0.49	—	—

The rocks of the Moon's surface contain almost pure anorthite of Ca content ($CaAl_2Si_2O_8$), a plagioclase feldspar with negligible Na content. The above facts suggest that the material of the glassy tektites originates from the Moon, and through impacts of meteorites it had escaped from the Moon's surface and arrived into the Earth's atmosphere. After heating up, it disintegrated into microblenddroplets. The plastic and bubbling microblenddroplets were hardened by the large physical and chemical forces and as a result become extremely resistant. They arrive floating slowly to the Earth's surface due to their smallness. The long cooling and their hardened material ensure the conservation of their genetic characteristics. This is confirmed by the fact that the glassy tektites which come from Triassic and Miocene layers are identical to those on the surface

with respect to their morphology, composition, texture and genetic characteristics, as if the 200 million years have not passed. This proves that they were formed from the same material by the same genetic process.

In conclusion it can be stated that the abundance of glassy tektites in layers of different ages can be linehad with some big meteorite impacts on the Moon's surface (KÁKAY-SZABÓ, 1996).

2. The **micro magnetospherules** have been recovered partly from a placer of the Maros river mouth and partly from the sand of a playground Budapest. EDAX examination of the material has shown but iron content.

The morphogenetics of magnetospherules clearly shows the origin and process of their formation. While during the magmatic processes on the Earth's surface an abrupt cooling of the material takes place and therefore a crust is formed, the meteorite which arrives in a cold state into the Earth's atmosphere is abruptly heated up but then breaks into parts which cool down slowly. Thus small droplets are obtained which show in a very delicate manner their genetic features.

The granule of smooth surface (PLATE I), from the Maros river mouth is a solid magnetospherule, 150 micron size with high density. Its fluidal texture and smooth surface show that it was plastic and spun during its origin, but by its greater weight and gasless material it arrived faster to the Earth's surface. The time of cooling was shorter and there was no time for crystallisation. Therefore there is no crystallisation pattern on its surface.

The surface pattern of the particle contains gas bubbles and is 120 micron in size (PLATE VII). Its fluidal texture attests to a plastic state of origin. Its plastic magnetic iron material in the direction of the strong spinning was ordered in to octahedral blocks the junctions of which yielded the surface pattern. The high velocity spinning produced, centrifugal force which affected the ruptures of the junctions. The inner parts of the spherule show also the effects of centrifugal force. A considerable part of the gas content got into the central part, forming a cavity there. A smaller part in the form of small bubbles remained in the material. Discoidal plates were formed by the centrifugal force from the octahedral plate crystals of the material. The sawtoothed edges of the discoidal plate were formed by the sliding of the octahedral plate crystals. The original fluid state of the magnetospherules is proved by the droplet growing to drop from the edge of a discoidal plate and the crystallite immersed in the plastic iron material. A complete conservation of the effects of forces on the magnetospherules is a consequence of their slow cooling. The long travelling of the spherule was a consequence of its gas content, light weight and small size. The resulting slow and uniform cooling assured that all details of its origin were conserved.

3. The **micro siderospherule** comes from the placer in the Maros river mouth. This little black sphere of 100μm size is of a glassy character. Its material contains both iron and silicates. At different points of the drop it has different compositions (PLATE VIII). On its surface rich in magnetic iron of terrestric origin it has a magnetic iron coating of terrestric origin in circularar patches. Those surfaces of the drop which are rich in silicates are blends of Mg, Al, K, which are rich in Si, Ca and have the same composition as the glassy microtektites. This fact, its fluidal texture and the blendfibre on its surface prove its cosmic origin. On those parts which contain iron, there are oval magnetic iron coatings of terrestric origin. The part of the surface which contains silicates is free of terrestric magnetic iron coating, it does not attract the terrestric magnetic iron material.

Consequently, the surface of the siderospherule shows in a spectacular way the mixed composition of the granule due to the terrestric overlays.

4. The **terrestric micro magnetopearls** come from the Pannonian clay of Arak, from a depth of 70 m. Their material is ferromagnetic alpha iron. On the surface on the pearls of 300–400μm size there are uniformly arranged junction lines, with some leaks at some parts. There are also pearls with empty centre (PLATE IX). The inner and outer surfaces are built up of small octahedral crystal plates. The octahedral crystal plates, which are lined up one after the other, have rectangular units and in triplets form an octahedral face, which in turn are arranged beside each other yielding circular units; these joined together form the pearl. The vertices of the octahedral crystal plates point to the inner part of the pearl forming a rough surface. These are formed in sediments of reductive environment by the crystallization of the iron solutions in the sediment pores. On the side of most magneto pearls there is a hole which shows the place where they were sticking during their formation. The magnetopearls are of terrestric origin according to their texture. They were formed by a slow and quiet crystallization at low temperature. They have no fluidal texture.

The microspherules are to be found almost everywhere on the Earth in sediments. The magnification of the order of several thousands reveals the origin and the genesis of each spherule by its genetic features.

ACKNOWLEDGEMENTS

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REFERENCE

HUTCHINSON, R. AND GRAHAM, A. 1992: Meteorites, Natural History Museum, London.

KÁKAY-SZABÓ, O. 1996: Morphogenetic Examination (SEM and EDAX) of Glassy Microtektites with high Ca Contents Obtained from Sedimentary Deposites and Placers. Chemie der Erde 56. 449–457.

MAYER CH. 1987: Moonrocks, Planetary Materials Branch, Solar System Exploration Division, Lyndon B. Johnson Space Centre, Houston NASA

PLATES

Plate II

1. Glassy microtektite of low density bubble crater and crystallites floating in the blenddrop and blendclothfibres
2. Glassy microtektite blenddrop with blendclothfibres spinned around it and with crystallites floating in it
3. Glassy microtektite of low density with big bubble crater and with blendclothfibres sticking to it
4. Blenddrop of low density with many blendclothfibres sticking to it and with crystallites floating in it

Plate III
1. Surface of a blenddrop of glassy microtektite of low density with blendclothfibres spinned on it and with crystallites floating in it
2. Blendclothfibre spinned on the surface of a plastic blenddrop
3. Blendclothfibre jumped on the surface of a plastic blenddrop
4. Blendclothfibre crashed on the surface of a plastic blenddrop
5. Bubble crater on the surface of a boiling blenddrop with blendclothfibre floating in it and with small crystallites

Plate IV
1. Blendcloth jumped on a blenddrop
2. Blendcloth built from crystallites
3. Blendclothfibre; spinned blendcloth
4. Blendclothfibre built up from crystallites
5. Crystallites pressed out from spinned blendcloth of higher density
6. Vertex of a blendclothfibre with the crystallites grown beside

Plate V
1. Surface of microtektite blenddrop of high density with oldhamite pseudomorphoses and with blendclothfibres pushed on it
2. Oldhamite pseudomorphoses floating in a blenddrop
3. Oldhamite pseudomorphoses floating in plastic blend and crystal germs
4. Developing oldhamite pseudomorphoses floating in a blenddrop
5. Twin oldhamite pseudomorphoses floating in a blenddrop

Plate VI
1. Monocrystal oldhamite pseudomorphose
2. Oldhamite pseudomorphose with cross twin structure
3. Glided oldhamite pseudomorphose twin

Plate VII
1. Magnetospherule with patter surface having some gap at joints showing the effect of centrifugal force
2. The surface of magnetospherule, its plastic material ordered in octahedral picces on the surface in the direction of spinning
3. The hole where the gaseous material of the magnetospherule centered; on the walls in the inner part of the drop there are discs formed under the centrifugal force from the octahedral plates
4. The sawtoothed edges of the discs are made up from the octahedral plate crystals which glide out
5-6. The droplets which appear on the edges of discs prove the plasticity of the material at the time when the spherule was formed

Plate VIII
1-2. The surface of the siderospherule spectacularly indicates that its material is mixed rich in silicium and iron. The surface which is rich in silicium has no terrestric magnetic iron cover, on the other hand the part rich in iron is covered by terrestric magnetic iron which is attracted

Plate IX
1. The surface of the terrestrial magnetopearl with lines of the joints and spots of stickings
2. The outer surface of magnetopearl with circular units joining to each other
3. Rectangular crystalline plate units forming a circular structure by joining on their octahedral sides; the pearl is formed from these by joining
4. The inner crystalline surface of magnetopearl
5. The smallest constituents of the magnetopearl, the octahedral plate crystals, which form rectangular units by growing behind each other
6. Rectangular plates, the small units grown together in octahedral form

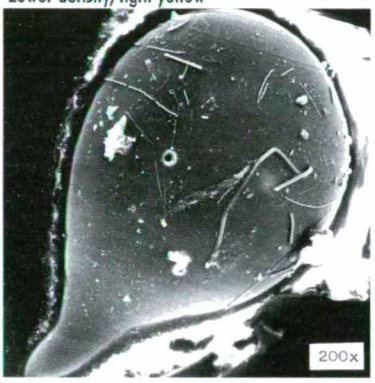
THE MAIN GENETIC TYPES OF SPHERULES FROM HUNGARY

by O. KÁKAY SZABÓ

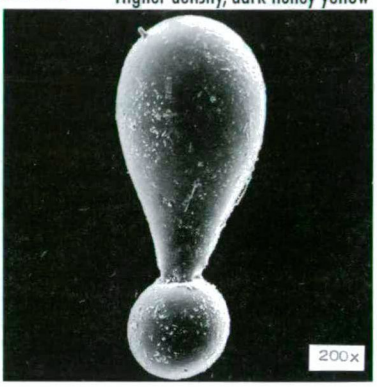
SEM photo: V. TAKÁCS EDAX: K. SOLYMOS Photo-copy: M. PELLÉRDY

GLASSY MICROTEKTITES

Lower density, light yellow

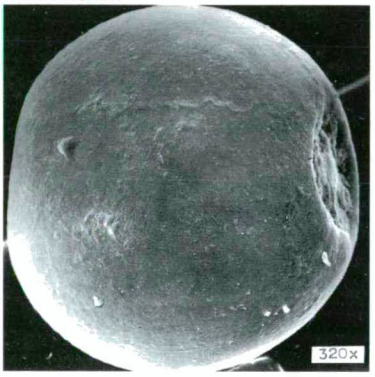


Higher density, dark honey yellow

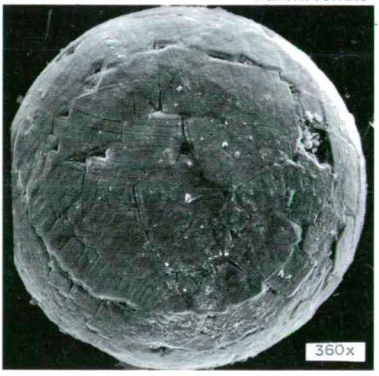


MICRO MAGNETOSPHERULES

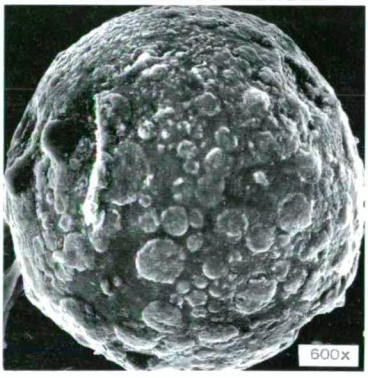
Smooth surface



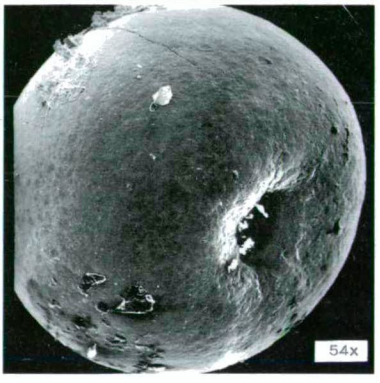
Pattern surface



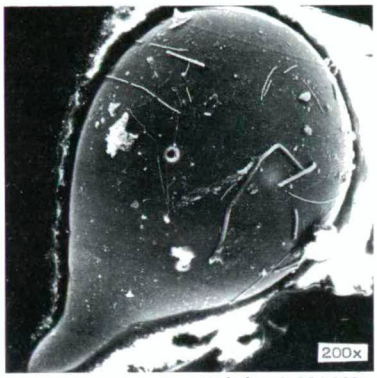
MICRO SIDEROSPHERULE



TERRESTRIC MICRO MAGNETOPEARL



CHEMICAL COMPOSITION OF THE GLASSY MICROTEKTITES



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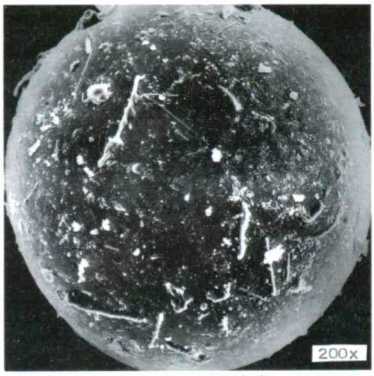
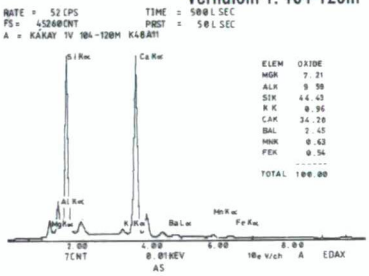
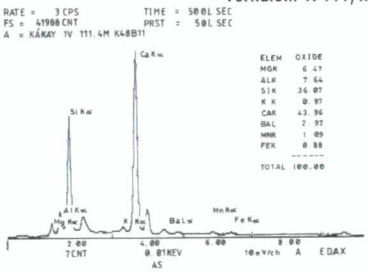


2.

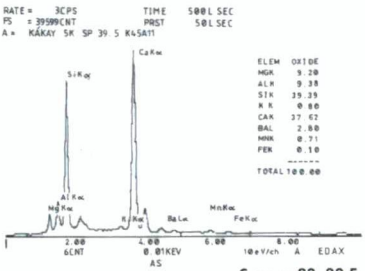
Vérhalom 1. 104-120m



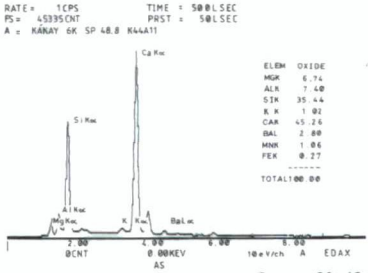
Vérhalom 1. 111,4m



TRIASSIC



Sopron 89. 39.5



MIOCENE

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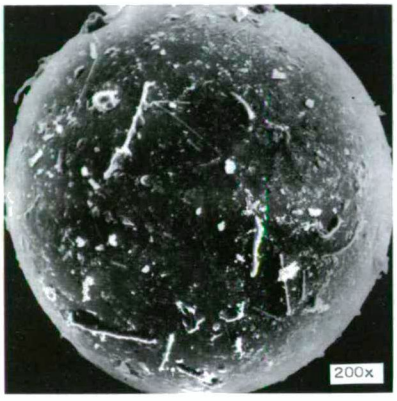
GENETIC STRUCTURE OF THE GLASSY MICROTEKTITES

Surface of the lower density glassy tektites



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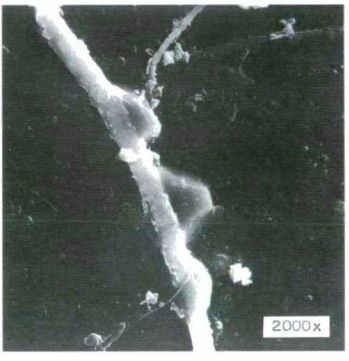

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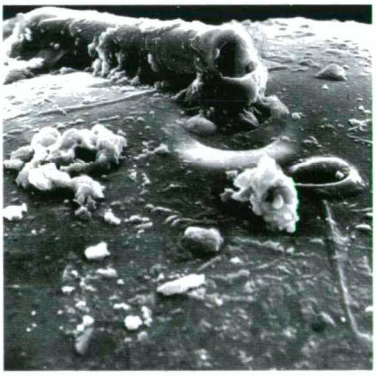

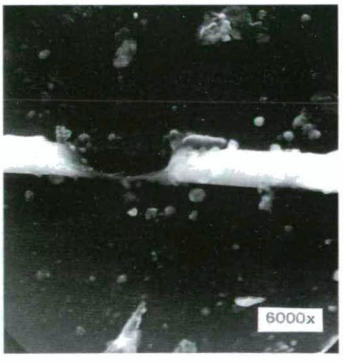

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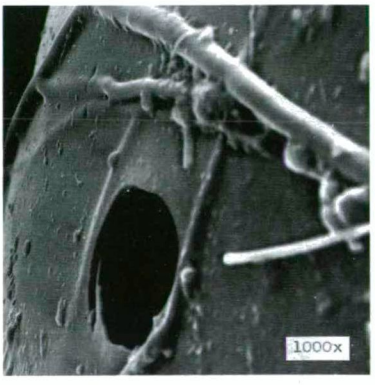

GENETIC STRUCTURE OF THE GLASSY MICROTEKTITES

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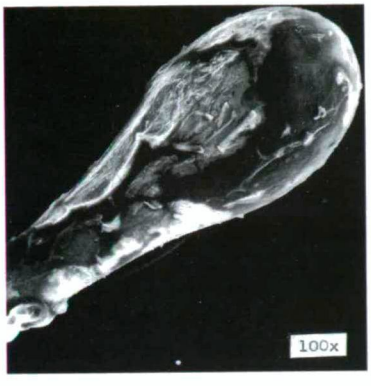

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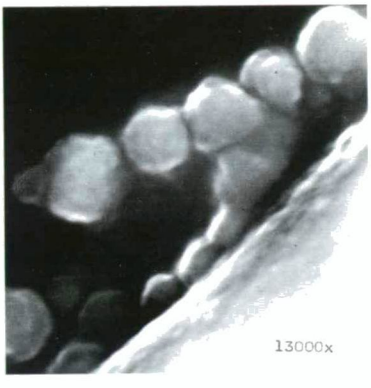

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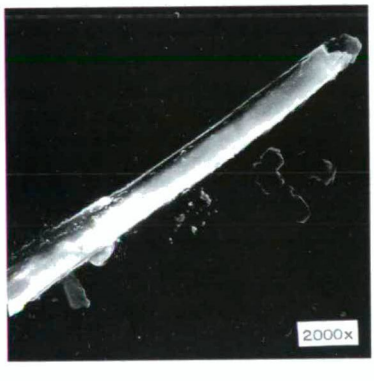

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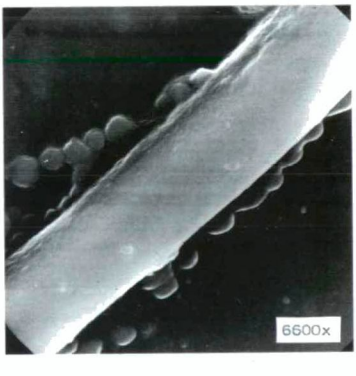

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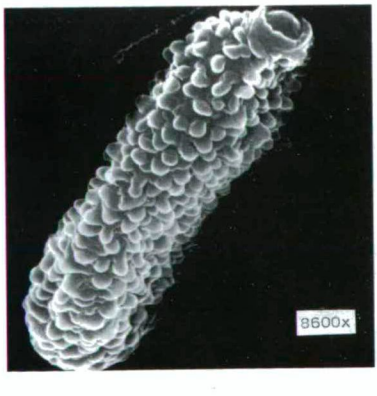

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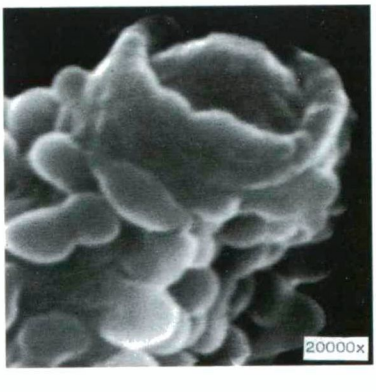

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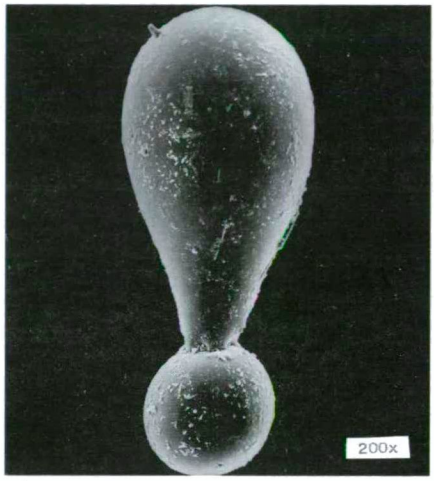

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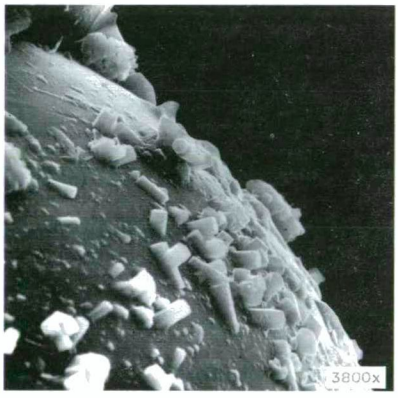

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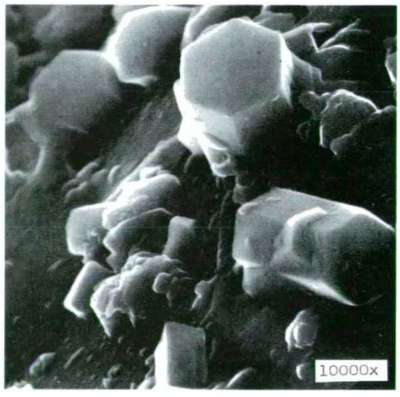

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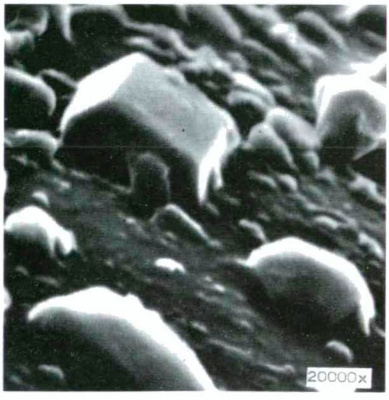

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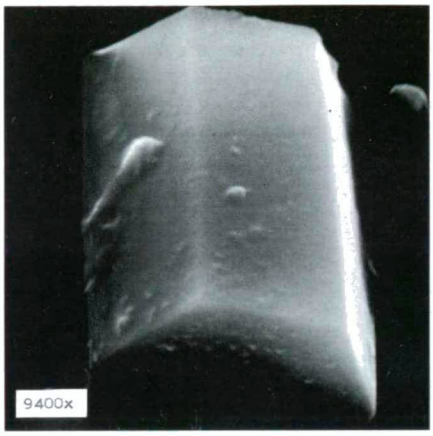
OLDHAMITE PSEUDOMORPHOSE



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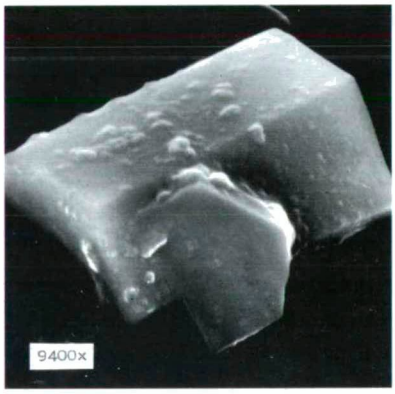

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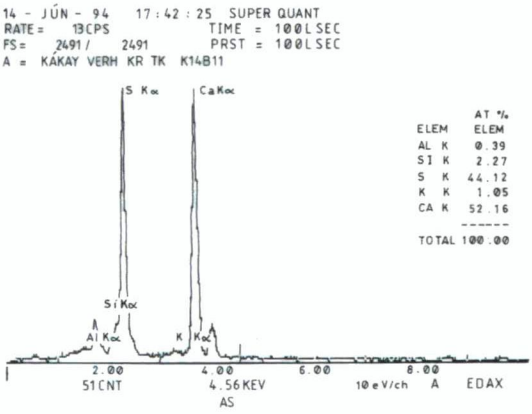
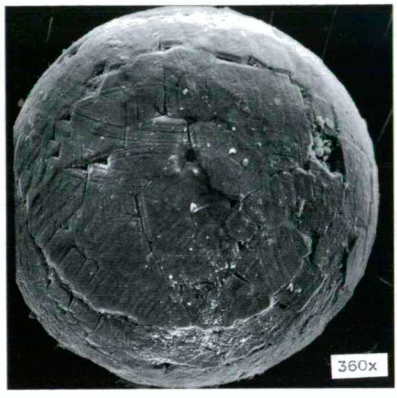


CHEMICAL COMPOSITION OF THE MAGNETOSPHERULE



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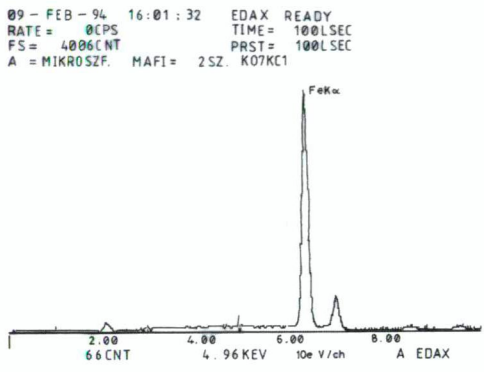

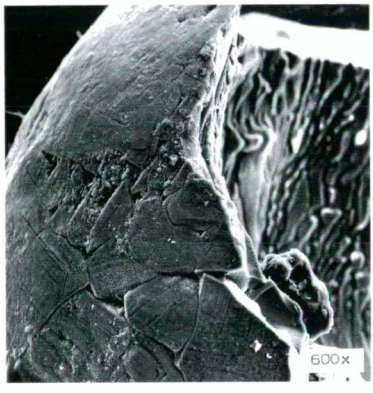

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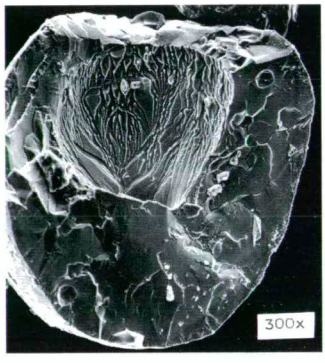

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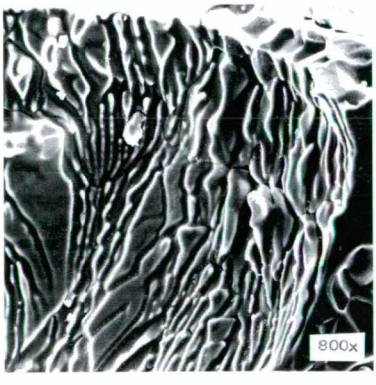

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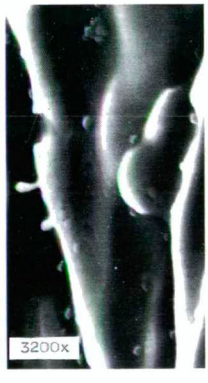

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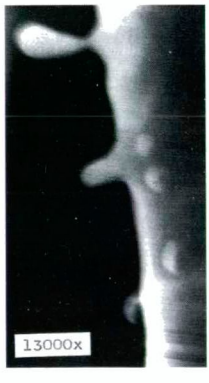

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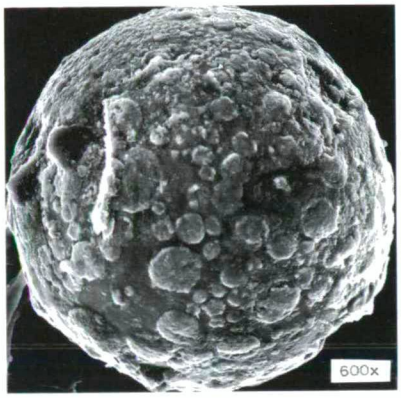
CHEMICAL COMPOSITION OF THE SIDEROSPHERULE



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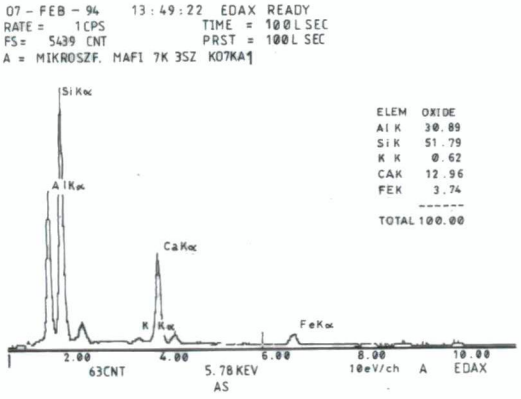
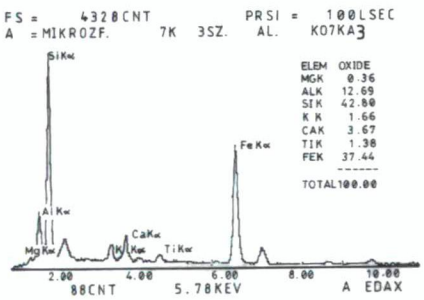
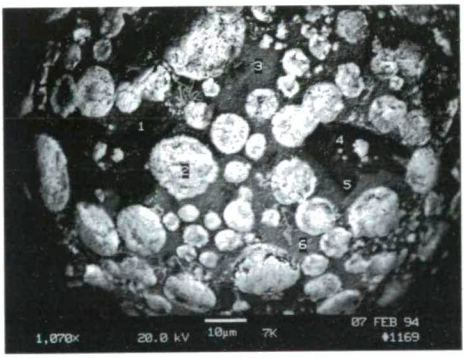
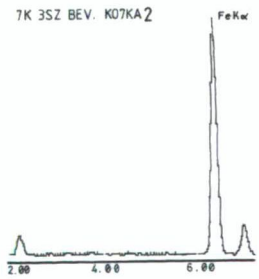
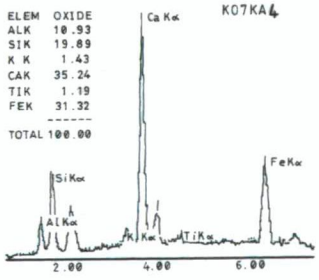
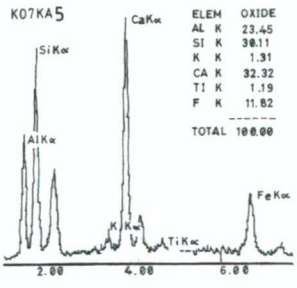




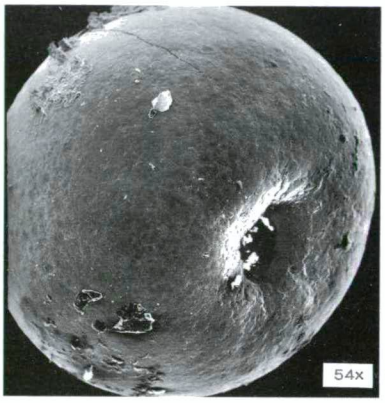








CHEMICAL COMPOSITION AND STRUCTURE OF THE TERRESTRIAL MICRO MAGNETOPEARL



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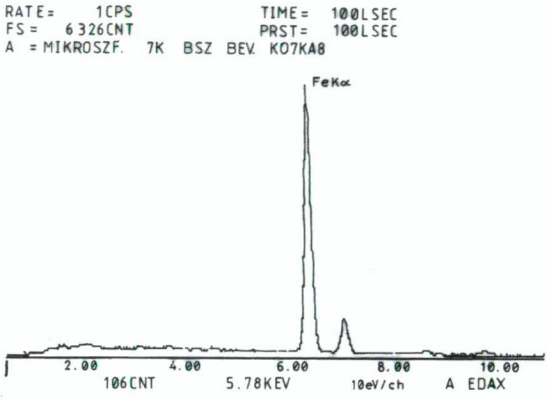

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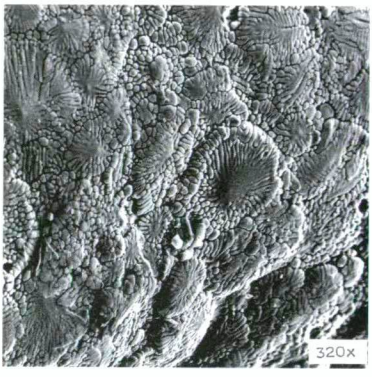

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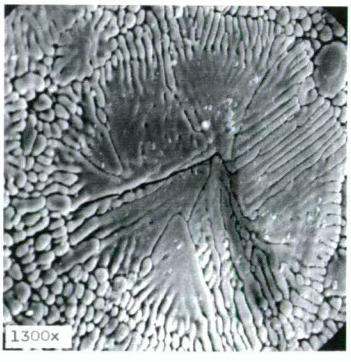

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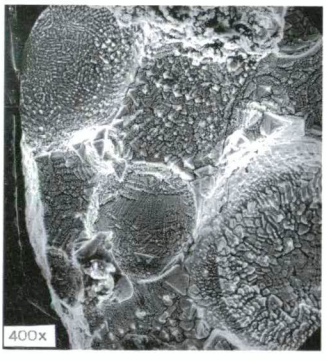

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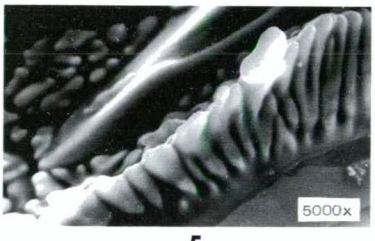

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Acta Mineralogica-Petrographica, Szeged, XXXVIII, Supplementum, 119–133, 1997

ORE MINERALS FROM THE KEY SECTION OF THE BAKSA COMPLEX (W BARANYA HILLS, HUNGARY)

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ABSTRACT

This paper is a documentation-like presentation of the study and description of ore minerals found in the geological key borehole Baksa 2. The ore minerals can be divided into two genetic groups by the studies. The lateral secretion phase can be regarded to be monophase represented by ilmenite. The other phase is formed by ore minerals coming from hydrothermal activity. These minerals are partly disseminated, and partly occur in veins. According to ore microscopic studies, the ore mineral paragenesis of the hydrothermal phase are the following: pyrite, marcasite, pyrrhotine, sphalerite, chalcopyrite, galena, pentlandite, hematite, covellite. The most significant ore indication of the borehole can be found at the depth of 186.4 m. It is a massive sulphide vein of 7 cm thickness with an independent mineral paragenesis formed by pyrite, marcasite, sphalerite, pyrrhotine, chalcopyrite and galena. On the basis of the exposed ore mineral paragenesis and the performed studies, the possibility of a perspective ore exploration can seriously arise.

INTRODUCTION

In 1978/79 a geological key borehole was drilled near Baksa village in the frame Hungarian Palaeozoic Key Section Research program organised by the Hungarian Geological Survey (Fig. 1). The borehole, which produced core sample along its total length, reached 1200 m depth, and exposed the metamorphic formations of the Baksa Complex forming the basement of the West Baranya Hills in a thickness of 1143 m. Complex geological and geochemical study of the obtained rock samples was performed by leadership of the Attila József University in 1979 (SZEDERKÉNYI, 1979). This borehole is regarded as the key section of the Baksa Complex.

Metamorphic rocks are dominant in the exposed formations. Major part of the borehole is represented by mica-schist and gneiss, while a minor part is formed by metamorphic carbonates, hornblende-schist, amphibolite and aplitic rocks. The pre-metamorphic sequence of the rock column is dominated by pelitic-psammitic (argillite-greywacke) rocks which suffered polymetamorphism (SZEDERKÉNYI, 1977). Preliminary ore microscopic study on the core samples of the borehole Baksa 2 showed that the exposed formations contained ore indications formed by hydrothermal activity (GRASSELLY, 1979). Their detailed mineralogical and genetic study was performed by the author in the Department of Mineralogy, Geochemistry and Petrology of the Attila József University in 1995/96 (TARNAI, 1996).

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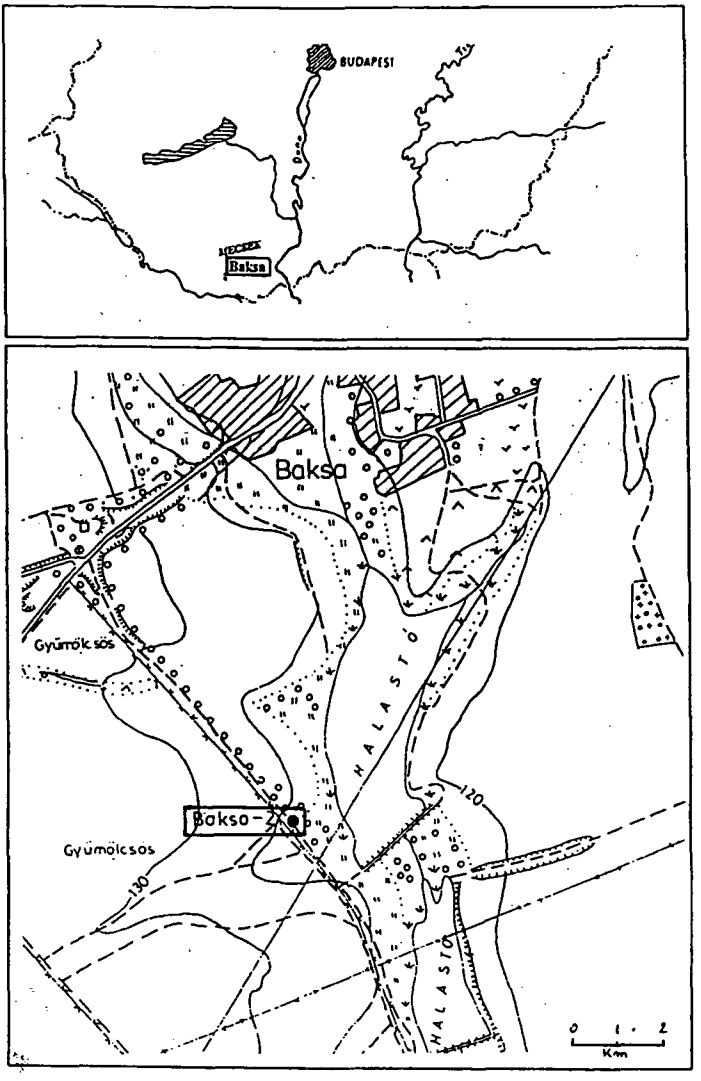

Figure 1: Location map of the borehole Baksa 2.

CHARACTERISATION OF THE BAKSA COMPLEX

The Baksa Complex – Görcsöny Crystalline-schist Formation (FÜLÖP, 1994) – is situated in the central part of the western third of the Tisza Unit (Tisia Composite Terrane) extending to south of the Central Hungarian Lineament, between the Mecsek and the Villány Subunits (Fig. 2). Information on its situation, subsurface extension, facies of its uppermost part as well as on the overlying formations comes from geophysical measurements, water prospect holes and geophysical control drillings (VADÁSZ, 1960;

JÁMBOR, 1962; BARABÁS et al., 1964; RAVASZNÉ BARANYAI, 1969; SZEDERKÉNYI, 1974, 1976, 1977, 1983; VÁRSZEGI, 1978; JANTSKY, 1974, 1979; ÁRKAI, 1984; SZEDERKÉNYI et al., 1991; KOVÁCS et al., 1996). According to the above mentioned studies the overlying beds are formed by Tertiary (mainly Upper Pannonian), Pleistocene and Holocene sediments. In general, their thickness ranges from 50 to 150 m, and they superposed on the basement by sharp erosional discordance. South of Rózsafa-Pécs, west of Pécs-Szalánta, north of Szalánta-Kisdér and north-east of Kisdér-Rózsafa line, the Palaeozoic basement is formed by the tectonically elevated formations of the Baksa Complex (Fig. 3). Surface outcrop of the rocks of the Complex has not been known anywhere. Morphologically and genetically, it has close relation to the Babócsa Complex (situated south-west of it) built up mainly gneiss and schist, however, there are differences, too, regarding the elevated position and the more varied geological setting of the Baksa Complex. The Baksa Complex is dominantly built up by polymetamorphic rocks, mainly mica-schist and gneiss interbedded by marble, metamorphic lime-silicate, amphibolite and eclogite formations. An interesting geological object of the area is the Gyód Serpentinite Formation situated in the above mentioned rocks. According to Szederkényi (1976) the metamorphic rocks of the Baksa Complex form a Barrovian facies sequence. Line of strike of the formations is NW-SE, they have steep (almost perpendicular) dip, and from south-west to north-east they form complete progressive metamorphic facies series from the chlorite to the sillimanite zone and the granitization.

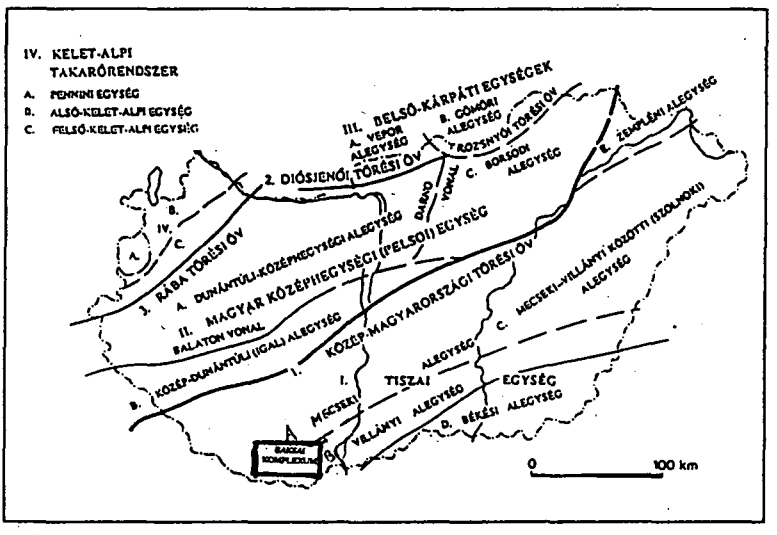

Figure 2: Tectonic units of Hungary (J. FÜLÖP, K. BREZSNYÁNSZKY, J. HAAS, 1989)

DESCRIPTION OF ORE MINERALS OF THE GEOLOGICAL PROSPECT BOREHOLE BAKSA 2

Basis of the research was represented by macroscopic, polarised microscopic and ore microscopic studies which were completed by inclusion, ICP and preliminary RFA

analyses, and by re-evaluation of the former chemical analyses. As a result of these studies, these ore minerals can be grouped described by the following way.

Ore minerals of the key borehole Baksa 2 can be divided into two genetic groups. One group is represented by lateral secretional ore minerals, the other is formed by hydrothermal ones. The hydrothermal ore minerals can be disseminated and can occur in veins, too.

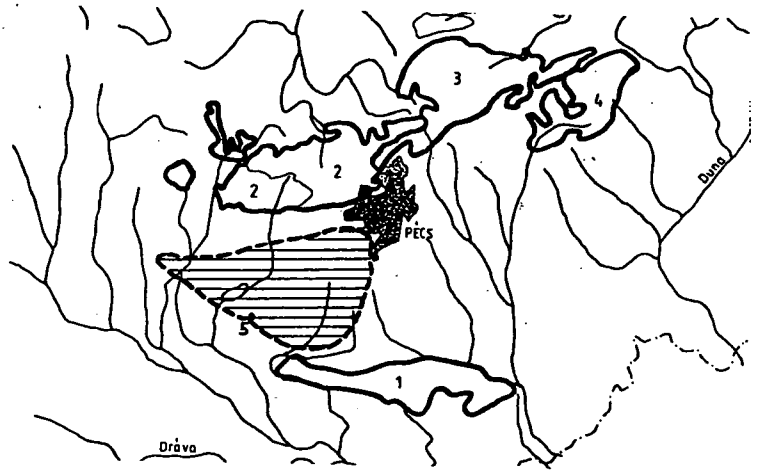

Figure 3: Subsurface extension of the Baksa Complex in the SE Transdanubia.
1. Surface extension of Mesozoic formations of the Villány Mountains; 2. Surface extension of Palaeozoic and Mesozoic formation of the W Mecsek Mountains; 3. Surface extension of Mesozoic formations of the E Mecsek Mountains; 4. Surface extension of the Mórágy Block; 5. Geological key borehole Baksa 2.
Formations of the Baksa Complex covered by Tertiary and Quaternary beds are shown by the shaded area.

THE LATERAL SECRETIONAL ORE PHASE

This phase is a monophase represented by ilmenite. (It can be noted that, regarding the whole rock column, metamorphic segregation could play a role in origin of the disseminated pyrite which can be found in many places. On the basis of the features observed by the studies, however, pyrite can rather be connected to the hydrothermal activity.)

Quantity of the ilmenite is very variable in the exposed rock column. It can be found in the whole borehole but it mainly associates with amphibolite, amphibolite-schist or any amphibolitic rock: in these cases its quantity can be as high as 3–5 %. It also occurs in mica-schist and gneiss, although in a subordinate amount. It is not characteristic, however, in carbonate rocks. In the studied thin sections, orientation of the ilmenite is always parallel to the cleavage planes, and it has elongated shape. Ilmenite is closely packed with the metamorphic minerals, and it never passes or breaks through them (TABLE I/1). Shape of its grains is always xenomorphic, and their size ranges from 150 to 300 μm. In the ore microscope its surface is always smooth and even, and it is grey. It has characteristic and uncommon pleochroism which is similar to that of pyrrhotine to a certain extent. In the 50 % of the samples, ilmenite shows the features of regressive metamorphism, i. e.,

leucoxenism and titanitization. In many cases, these secondary products surround ilmenite as a cover (TABLE I/2).

HYDROTHERMAL ORE PHASE

The other group of ore minerals of the exposed formations is represented by the hydrothermal phase. These minerals are disseminated or occur in veins (TABLE II/1). In general, thickness of the veins ranges from 0.1 to 1 mm, however, there is a 7 cm thick massive sulphide veins at the depth of 186.4 m. Their occurrence does not relate to characteristic rock, however, there are more veins near the surface. Their ore mineral paragenesis is the following: pyrite, marcasite, sphalerite, chalcopyrite, pyrrhotine, galena, hematite, pentlandite, covellite.

The disseminated pyrite can be found in a lower amount in the formations, however, it is one the major minerals in the veins. Pyrite in veins is mainly characteristic near the surface (TABLE II/2). It occurs together with chalcopyrite in many cases. Its shape can be xenomorphic, hypidiomorphic and idiomorphic, too. Pyrite crystals are bigger in veins (200–600 μm), while the disseminated pyrite grains are smaller (20–50 μm). In general, the pyrite crystals are fresh, their marcasitization is subordinate. The only one exception is the vein at the depth of 186.4 m, where marcasite originating from pyrite and pyrrhotine is one of the major ore mineral constituents (TABLE VIII/2).

Out of the above mentioned vein, marcasite (TABLE III/1) is very rarely. Here and there, it can be found as small grain. In the 7 cm thick vein, however, its amount is 10–15 %. It should be regarded as a secondary mineral because pyrite and pyrrhotine could turn into marcasite.

The disseminated sphalerite can be found very rarely, and it has a lower quantity even in the veins (TABLE III/2). In general, it is inclusion-free and xenomorphic (there is only one sample in which sphalerite is hypidiomorphic). It is associated with chalcopyrite (TABLE IV/1) and hematite (TABLE IV/2). In the ore vein at the depth of 186.4 m, however, its quantity is 24 %, and it contains chalcopyrite-pyrrhotine inclusions of 2–2.5 % (TABLE V/1). Chalcopyrite and pyrrhotine in sphalerite can be regarded as partly demixing, partly epitaxial inclusions (TABLE V/2). In the major part of the vein pyrite is its accompanying ore mineral but in the outer part it is accompanied by chalcopyrite and galena.

Excepting two samples, chalcopyrite is subordinated in the veins. It is associated with sphalerite and galena in the outer phase, mainly in the 7 cm thick vein at 186.4 m (TABLES IV/1 and VI/1). The disseminated chalcopyrite occurs in the form of small rags. Together with pyrrhotine, it can be found very often as inclusion in sphalerite. Displacing each other, its disseminated grains also occur together with pyrrhotine. Chalcopyrite is always xenomorphic, and its characteristic size ranges from 50 to 100 μm.

Galena (TABLES VI/1 and VI/2) occurs only in the 7 cm thick vein, and only in the external ore phase. It is always xenomorphic and disseminated. It is associated with chalcopyrite, sphalerite and pyrite. Its observed maximum size is about 2 mm.

Pyrrhotine can be disseminated ore mineral – in the vein at the depth of 186.4 m it occurs as inclusion of pyrite (TABLE VII/1) and sphalerite (TABLE V/1) –, and forms massive monomineralic ore veinlets (TABLES VII/2 and II/1) in the deeper part of the borehole. Thickness of the biggest veinlet is 1 mm. Pyrrhotine is always xenomorphic. In ore microscope, its surface is uneven and porous. Pentlandite inclusions in pyrrhotine can

well be observed at high magnifying (TABLE VIII/1). The disseminated pyrrhotine is frequently associated with chalcopyrite.

Hematite is quite subordinated in the studied samples. It occurs only in two samples from the near surface region. It is the only one non-sulphide, hydrothermal ore mineral in the rock column. It forms thin veins, and lamellar join structure is characteristic for it. Size of a lamella is 15–30 μm. At crossed polars its red reflection is excellently visible. Generally, it is associated with sphalerite (TABLE IV/2).

Pentlandite can be found in pyrrhotine veins at the depth of 900 m of the exposed rock column. It forms small (1–2 μm wide and 20–50 μm long) exsolution spindles and flames of similar size (TABLE VIII/1).

In one sample two covellite grains of 20 μm was found as alteration product of chalcopyrite.

CONCLUSION

Ore minerals exposed in the borehole Baksa 2 was formed by a significant hydrothermal activity affecting the Baksa Complex, with the exception of ilmenite coming from lateral secretional process. Hydrothermal origin of the ore minerals is indicated by the ore mineral paragenesis as well as their morphological and textural features. The frequent chalcopyrite-pyrrhotine exsolution, the double (pyrrhotine-chalcopyrite) inclusions of the sphalerite, and pentlandite inclusions of the pyrrhotine veins in the deeper region of the borehole suggest high temperature of fluids forming the ores. The two-phase-structure of the 7 cm thick vein at the depth of 186.4 m proves that the hydrothermal activity could happen in two phases at least. The mainly sulphide mineralisation characterised by Fe, Zn, Cu, Pb, (Ni) shows that fluids were in connection with real magmatic activity and not from mobilisation of a metamorphic fluid in a wider sense. Beside the varied ore mineral paragenesis, this assumption is also supported by compositional, textural and morphological features of non-ore minerals in the veins.

Accurate geological dating of the hydrothermal activity is quite difficult because of the available data and features of the samples. It can be stated, however, the hydrothermal activity affected the Baksa Complex after the progressive metamorphic effects of the Variscian tectonometamorphic cycle since the veins always cross the schistosity, sometimes they are pressed amongst the cleavage planes, and metamorphic phenomena can not be observed in the ore-bearing veins.

Determination of the regional connections is also difficult. On the basis of geological closeness and analogy of the mineralisational features it is possible hydrothermal processes found in borehole Baksa 2 are related to the Lower Permian rhyolitic volcanism (Gyűrűfű Rhyolite Formation) or the subsequent post-volcanic activities because centre of the above mentioned volcanism lies as near as 20 km to the east of the key borehole (boreholes Vokány 2 and Egerág 7). Moreover, hydrothermal ore indication related to the rhyolitic volcanism was found in the borehole Szava 1 which is 10–15 km to the east of the borehole Baksa 2 (FAZEKAS AND VINCE, 1991). It is also possible, however, that hydrothermal ore mineralisation of the Baksa Complex is totally independent of the Lower Permian volcanism. It could be interpreted as a product of the Lower Cretaceous or Miocene volcanism of the Mecsek Mountains, or product of a still unknown volcanic activity. This assumption is supported by a 7 cm thick andesite dike at 469.4 m of the borehole Baksa 2.

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REFERENCES

ÁRKAI P. (1984): Polymetamorphism of the crystalline basement of the Somogy–Dráva Basin (Southwestern Transdanubia, Hungary). – Acta Mineral. Petrogr. Szeged 26/2, pp. 129–153.

BALLA Z. (1981): Plate tectonics interpretation of the south transdanubian ultramafics. – Acta Mineral. Petrogr. Szeged 25/1, pp. 3–24.

BARABÁS A., JÁMBOR Á., SZÉNÁS GY. et al. (1964): A Mecsek és a Villányi-hegység geofizikai kutatásának eredményei. – MÁELGI Évk. 1.

FAZEKAS V., VINCZE J. (1991): Hidrotermás Ércindikációk a Villányi-hegység északi előtere mélyfúrásaiban. – Földtani Közlöny 91/1–4, pp. 23–56.

FÜLÖP J. (1989): Bevezetés Magyarország geológiájába. Akadémiai Kiadó, Budapest.

FÜLÖP J. (1994): Magyarország geológiája, Paleozoikum I–II. Akadémiai Kiadó, Budapest.

GRASSELY GY. (1979): in: A mecseki ópaleozoós–prekambriumi alapszelvények komplex földtani feldolgozása (SZEDERKÉNYI T.). Kézirat. JATE, Ásványtani, Geokémiai és Kőzettani Tanszék, Szeged. pp. 113–124.

HARANGI SZ. & ÁRVÁNÉ SÓS E. (1993): A Mecsek hegység alsókréta vulkáni kőzetei 1. Ásvány- és kőzettan. – Földtani Közlöny 93/2, pp. 129–165.

JANTSKY B. (1974): A mecseki kristályos alaphegység földtana. Akadémiai doktori disszertáció.

JANTSKY B. (1979): A mecseki gránitosodott kristályos alaphegység földtana. – MÁFI Évk. LX.

JÁMBOR Á. (1962): A Tésény–1. sz. fúrás földtani eredményei. – Földtani Közlöny 92/4, pp. 458–459.

KISS J. (1982): Ércteleptan I–II. Tankönyvkiadó, Budapest.

KOCH S., SZTRÓKAY KÁLMÁN I. (1967): Ásványtan I–II. (harmadik, javított kiadás, 1986). Tankönyvkiadó, Budapest.

KOVÁCS S. et al. (1996): Report of IGCP project. No. 276. Athenes (In press).

KUBOVICS I. (1993): Kőzetmikroszkópia I–II. Tankönyvkiadó, Budapest.

Magyarország mélyfúrási alapadatai, retrospektív sorozat, 3. kötet, Dél-Dunántúl, 1866–1973. A KFH megbízásából kiadja a MÁFI, Budapest, 1984.

RAVASZNÉ BARANYAI L. (1969): Eclogite from the Mecsek Mountains, Hungary. – Acta Geol. Acad. Sci. 13, pp. 315–322.

SZEDERKÉNYI T. (1974): Paleozoic magmatism and tectogenesis in Southeast Transdanubia, Hungary. Acta Geol. Sci. Hung., 18, 3–4, 305–313.

SZEDERKÉNYI T. (1975): A Délkelet–Dunántúl ópaleozoós képződményeinek ritkaelem-kutatása. Kandidátusi értekezés. JATE, Ásványtani, Geokémiai és Kőzettani Tanszék, Szeged.

SZEDERKÉNYI T. (1976): Barrow type metamorphism in the crystalline basement of Southeast Transdanubia. – Acta Geol. Acad. Hung. 20/1–2, pp. 47–61.

SZEDERKÉNYI T. (1977): Geological evolution of South Transdanubia (Hungary) in Paleozoic time. – Acta Mineral. Petrogr. Szeged 23/1.

SZEDERKÉNYI T. (1979): A mecseki ópaleozoós–prekambriumi alapszelvények komplex földtani feldolgozása. Kézirat. JATE, Szeged.

SZEDERKÉNYI T. (1983): Origin of amphibolites and metavolcanics of crystalline complexes of South Transdanubia, Hungary. – Acta Geol. Acad. Sci. Hung. 26/1–2, pp. 103–136.

SZEDERKÉNYI T., ÁRKAI P., LELKESNÉ FELVÁRI GY. (1991): Crystalline groundfloor of the Great Hungarian Plain and South Transdanubia, Hungary. Serbian Acad. Sci. and Arts Acad. Conf. 4, pp. 261–273.

TARNAI T. (1996): A Baksa–2. sz. földtani alapfúrásban feltárt ércásványok ásványtani és genetikai jellemzőinek vizsgálata. – Diplomamunka. JATE Ásványtani, Geokémiai és Kőzettani Tanszék, Szeged.

VADÁSZ E. (1960): Magyarország földtana 2. (átdolgozott kiadás). – Akadémiai Kiadó.

VÁRSZEGI K. (1978): Série cristalline de Görcsöny. In Fülöp J. (Ed.): Lexique stratigraphique international. Vol 1. Europe. Fasc. 9. Hongrie. (pp. 223–224). – Centre Nat. de la Rech. Sci.

VÖRÖS I. (1970): Ércmikroszkópiai határozó. Tankönyvkiadó, Budapest.

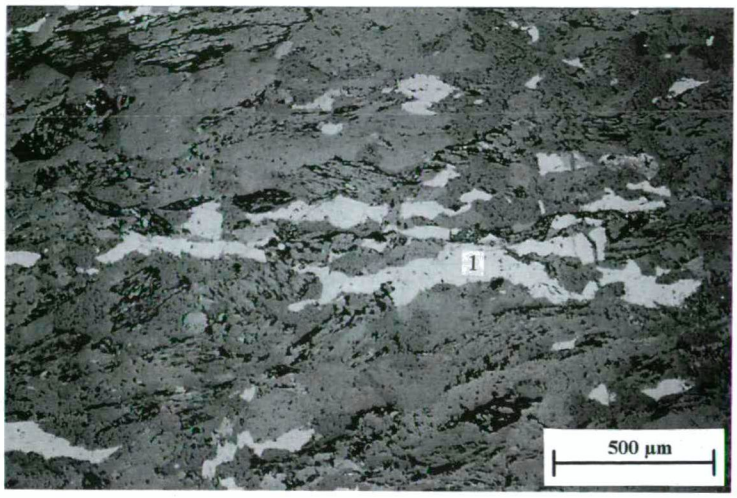

TABLE I/1: Polished section. Key borehole Baksa 2. Lateral secretional ilmenite orientating to schistosity (x40, ordinary light). Legend: 1. ilmenite.

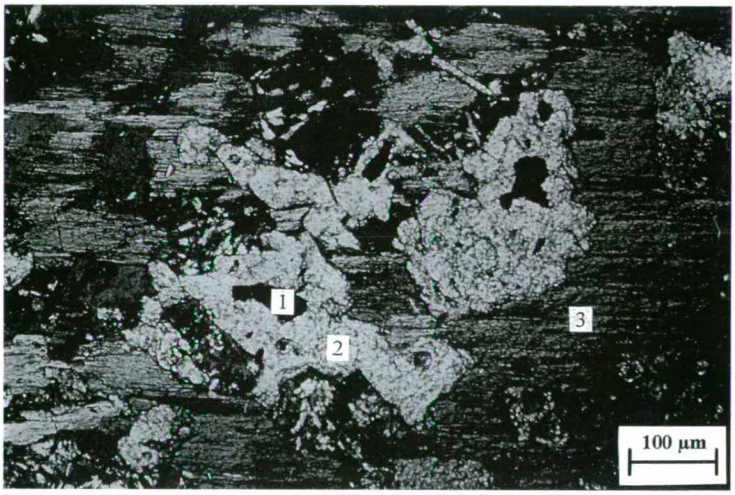

TABLE I/2: Thin section. Key borehole Baksa 2. Ilmenite surrounded by titanite (x200, crossed polars). Legend: 1. opaque mineral, 2. titanite, 3. amphibole.

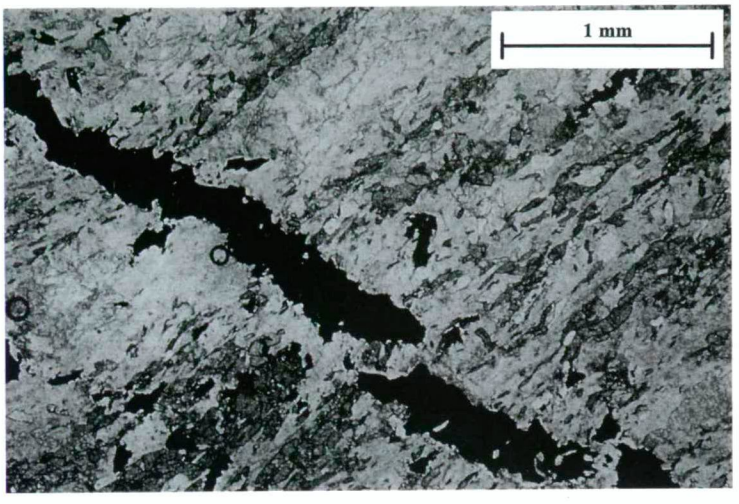

TABLE II/1: Thin section. Key borehole Baksa 2. Vein filled with ore minerals. The ore minerals penetrated amongst the cleavage planes, too (x50, ordinary light).

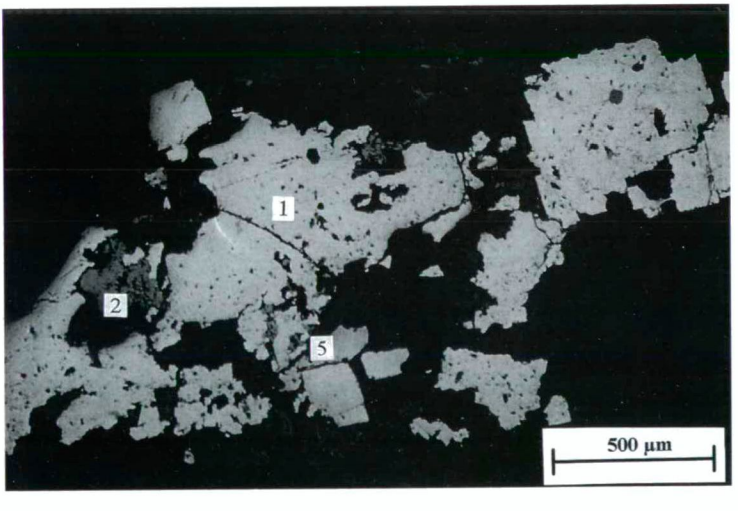

TABLE II/2: Polished section. Key borehole Baksa 2. Hypidiomorphic-xenomorphic pyrite grains in a vein (x40, ordinary light). Legend: 1. pyrite, 5. chalcopyrite, 2. sphalerite.

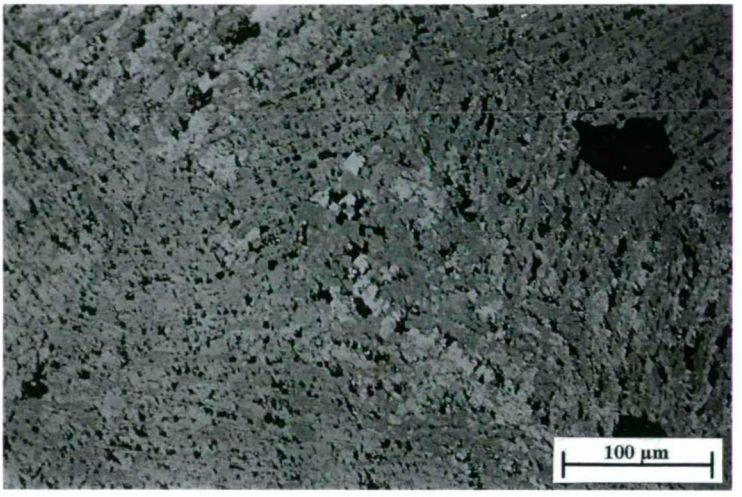

TABLE III/1: Polished section. Key borehole Baksa 2. Typical marcasite (x200, crossed polars)

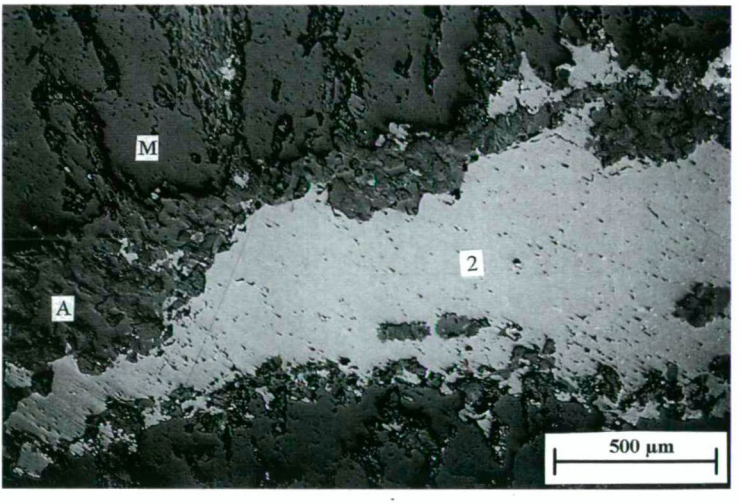

TABLE III/2: Polished section. Key borehole Baksa 2. Sphalerite with chalcopyrite inclusions (x40, ordinary light). Legend: 2. sphalerite, A. barren apophysis, M. wall rock.

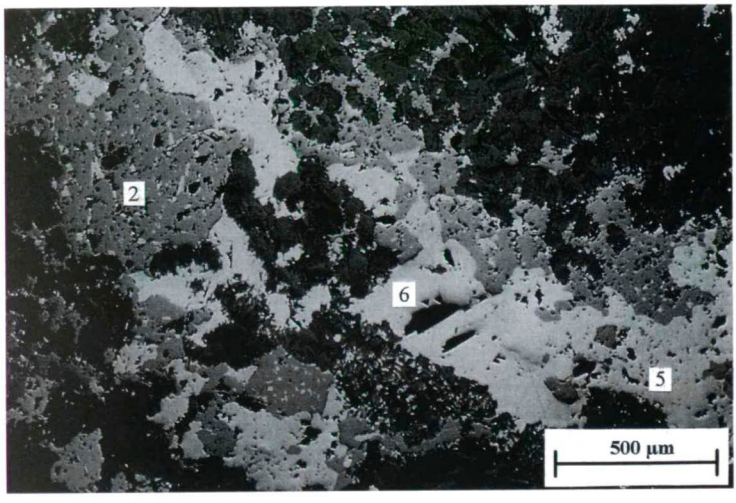

TABLE IV/1: Polished section. Key borehole Baksa 2. Ore minerals of a hydrothermal vein (x40, ordinary light).
Legend: 2. sphalerite, 5. chalcopyrite, 6. galena.

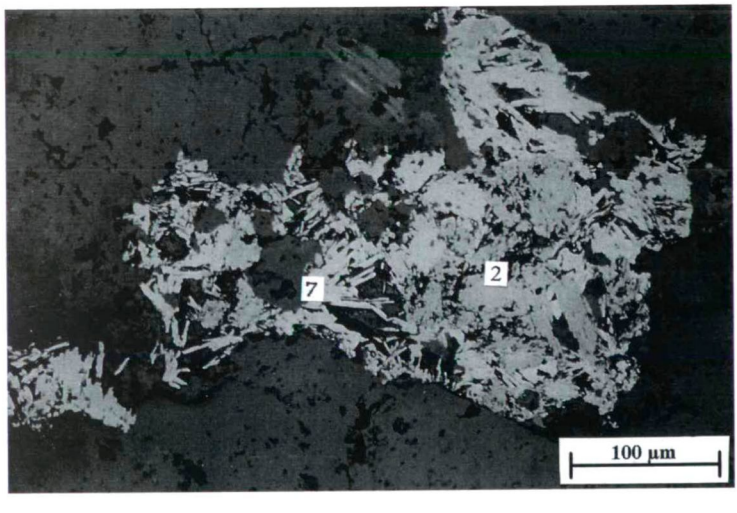

TABLE IV/2: Polished section. Key borehole Baksa 2. Hematite lamellae in sphalerite (x200, crossed polars).
Legend: 7. hematite, 2. sphalerite.

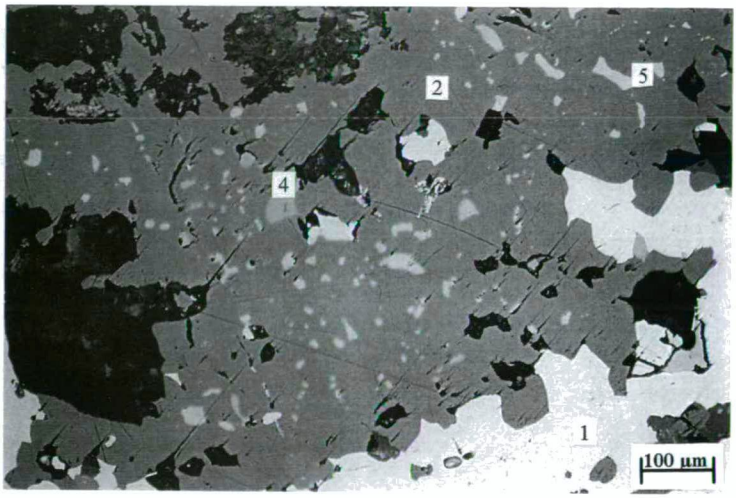

TABLE V/1: Polished section. Key borehole Baksa 2. Interlocking of pyrite and sphalerite containing chalcopyrite and pyrrhotine inclusions (x100, crossed polars).
Legend: 1. pyrite, 2. sphalerite, 4. pyrrhotine, 5. chalcopyrite.

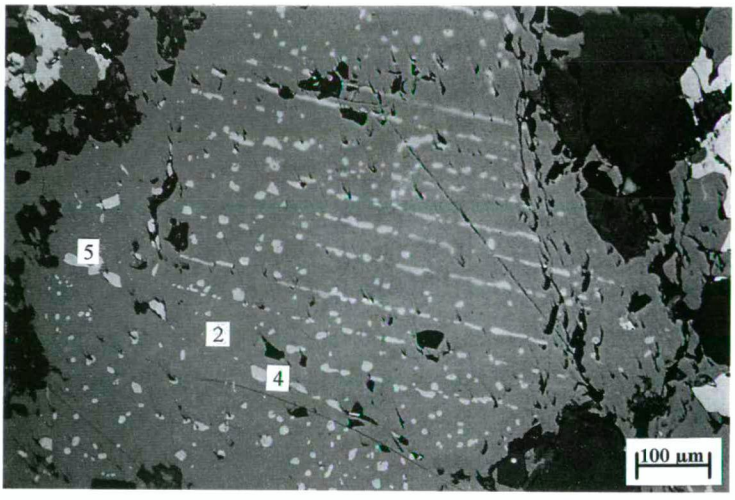

TABLE V/2: Polished section. Key borehole Baksa 2. Oriented inclusion of sphalerite (x100, crossed polars).
Legend: 2. sphalerite, 4. pyrrhotine, 5. chalcopyrite.

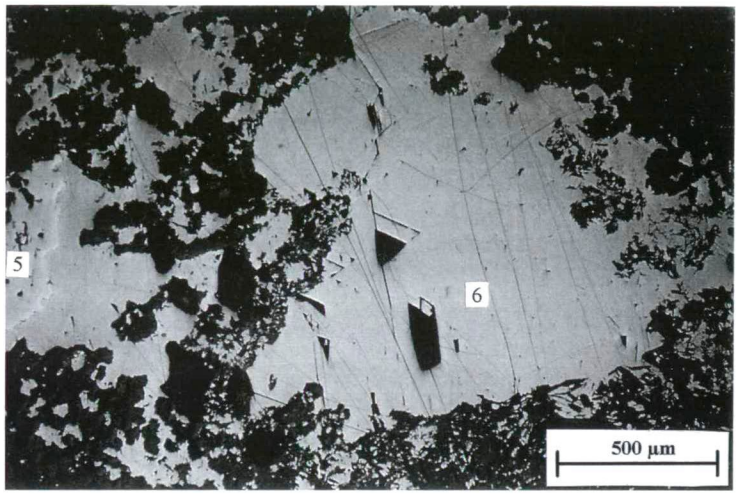

TABLE VI/1: Polished section. Key borehole Baksa 2. Galena and chalcopyrite (x40, ordinary light).
Legend: 5. chalcopyrite, 6. galena.

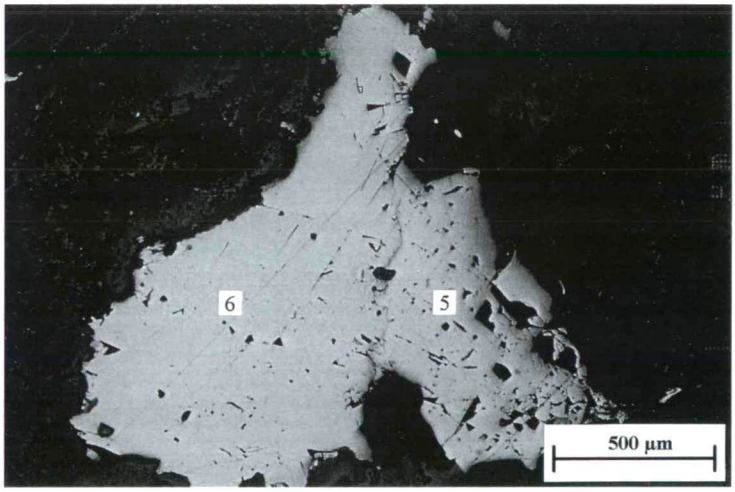

TABLE VI/2: Polished section. Key borehole Baksa 2. Galena (x40, crossed polars).
Legend: 5. chalcopyrite, 6. galena.

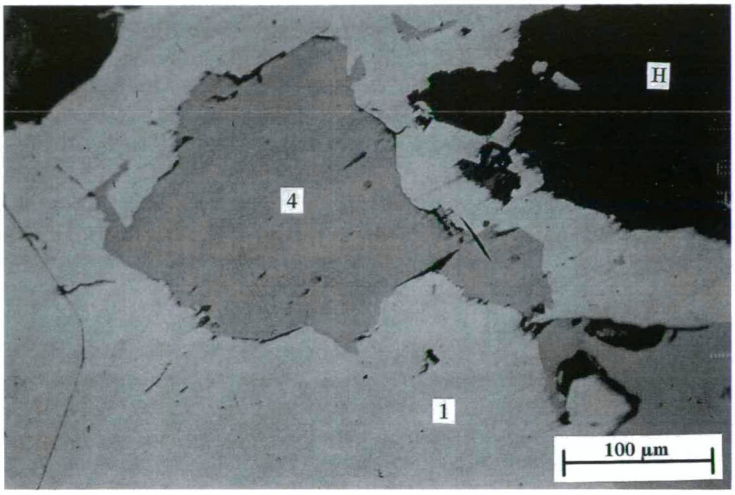

TABLE VII/1: Polished section. Key borehole Baksa 2. Pyrrhotine inclusion in pyrite (x200, ordinary light).
Legend: 1. pyrite, 4. pyrrhotine, H. gap.

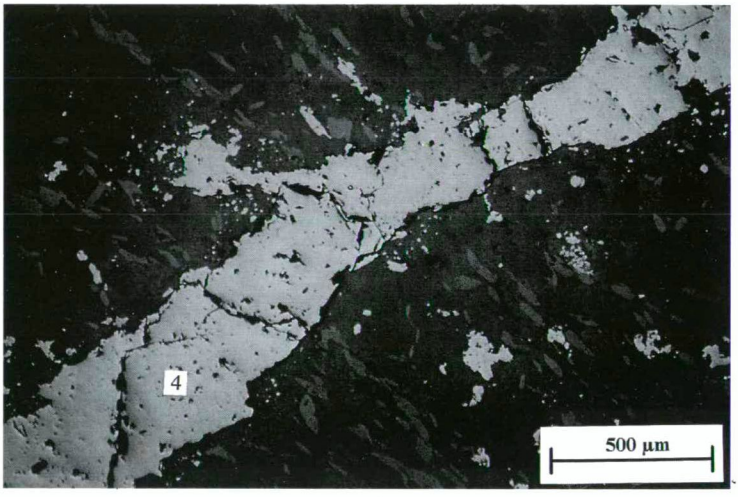

TABLE VII/2: Polished section. Key borehole Baksa 2. Pyrrhotine vein (x40, ordinary light).
Legend: 4. pyrrhotine.

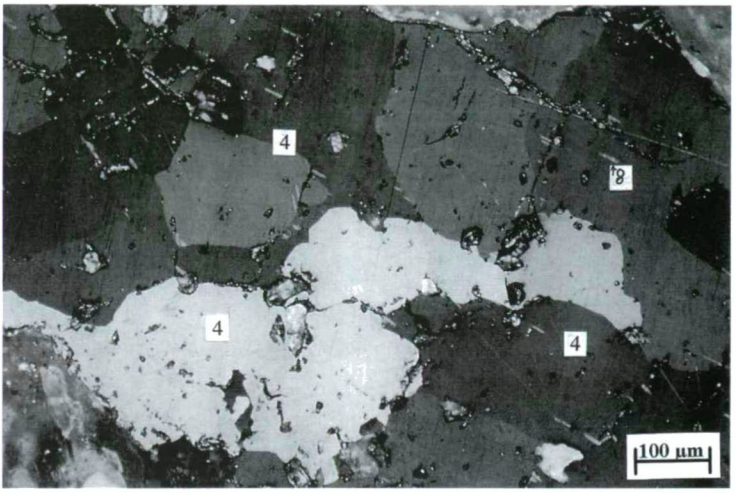

TABLE VIII/1: Polished section. Key borehole Baksa 2. Pleochroism of pyrrhotine. Pentlandite inclusions can also be observed (x100, parallel polars). Legend: 4. pyrrhotine, 8. pentlandite.

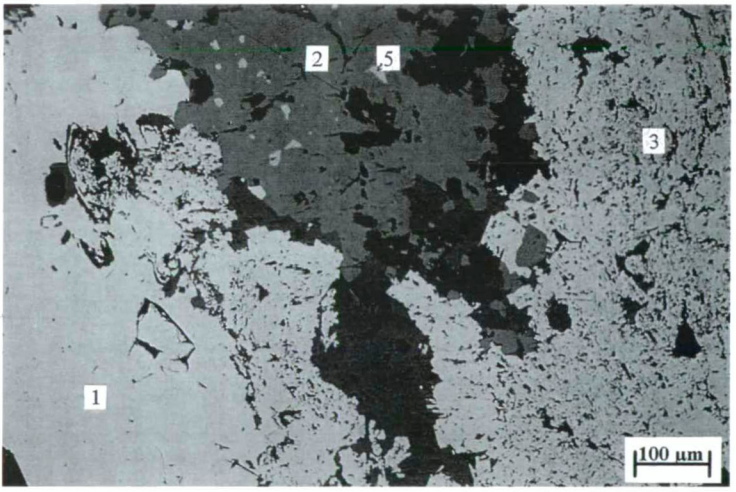

TABLE VIII/2: Polished section. Key borehole Baksa 2. Fresh and marcasitizing pyrite with sphalerite (x100, ordinary light). Legend: 1. pyrite, 2. sphalerite, 3. marcasite, 5. chalcopyrite (inclusion).

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DIFFUSION CONTROLLED DOUBLE CORONA REACTION RIM AROUND KYANITE IN RETROGRADED ECLOGITE FROM THE SWISS CENTRAL ALPS

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ABSTRACT

Retrograded eclogite samples at the village Gorduno in the Swiss Central Alps contain relics of ellipsoidal shape with double corona rim. The internal core consists of radial intergrowth of spinel and at places corundum. The fine-grained core is rimmed by plagioclase of composition An_{95} which is followed by an outer plagioclase rim. This second plagioclase is of An_{45-50}.

This mineralogy has formed due to a series of reactions between kyanite and other high pressure phases; pyroxene, garnet, zoisite. All these reactions separated the Al-, and Si-rich phases from each other. Because of the restricted mobility of Al the newly formed minerals created the double corona structure around kyanite.

Key words: eclogite, corona structure, mobility

INTRODUCTION

Amphibolite samples found in the Swiss Central Alps north of the village Gorduno contain mineral and textural relics of an earlier eclogite facies event. In addition to amphibole and plagioclase these samples also contain garnet, clinopyroxene, rutile and zoisite as HP phases. Pyroxene grains have been almost totally replaced by amphibole-plagioclase symplectitic intergrowth, garnet is surrounded by an amphibole-plagioclase corona, while rutile is rimmed by sphene. Zoisite has been replaced by a cluster of submicroscopic grains of undefined minerals. All these changes are typical of a breakdown of eclogite when decreasing pressure, and have been frequently observed in the Central Alps. In addition to the breakdown paragenesis common in retrograded eclogites, egg-shaped relics with double corona reaction texture also occur (PLATE I/1.). Their appearance in many localities as well as their mineralogy and textural characteristics were first described by FORSTER (1948).

This paper focuses on the possible development of the disequilibrium textural relics.

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ANALYTICAL METHODS

In addition to optical microscopy quantitative chemical analysis as well as X-Ray mapping for selected elements were performed on a CAMECA SX-50 electron microprobe. Instrumental conditions for single crystal analysis were an accelerating voltage of 15 kV and a beam current of 20 nA. In the spectrometers LiF, PET and TAP crystals were used. Natural minerals (DIAMOND et al., 1994) were used as standards. On X-ray mapping acquisition time varied from 10 to 20 minutes depending on the concentration of the selected element.

PETROGRAPHY

Major part of the samples studied consists of amphibole and garnet. At places amphibole is intergrown with clinopyroxene; garnet usually has a radial rim of plagioclase and amphibole. Chemical composition of the relict garnet grains is consistent with an earlier HP metamorphic event, pyroxene, however, is low in jadeite component. Garnet is of composition $Alm_{45}Pyr_{26}Grs_{27}Sps_2$, pyroxene is diopside and hedenbergite (about 1:2 in proportion), with a very low amount of Al and Na.

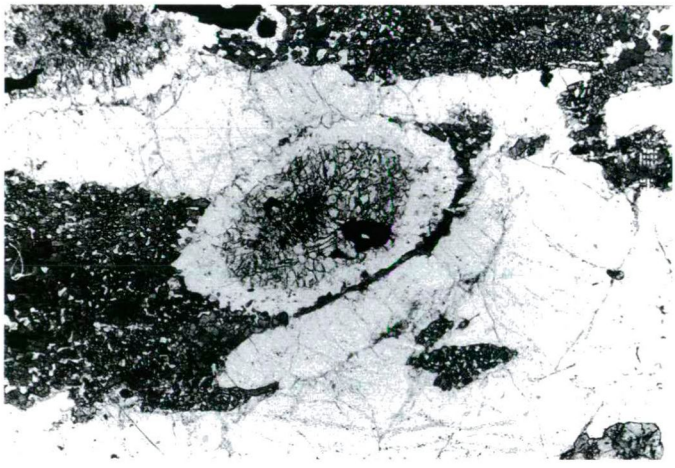


Plate I/1. Double corona microtexture with a dark grey internal and a white external rim. The textural relic is inbedded in a rock composed by amphibole and quartz. N1, 100x. 1-internal rim; 2-external rim; 3-amphibole; 4-quartz

The microfabric studied has ellipsoidal shape and a well-defined border towards the other phases around, usually quartz, amphibole and garnet (PLATE I/1., I/2.). The outer shell of the compouned corona structure consists of plagioclase with granoblastic texture, followed by an inner feldspar zone. The boundary is evident in a plain light owing to a sharp increase in relief (refractive index) and by a textural change as well (PLATE I/3.). Plagioclase grains of the inner shell are smaller in size and form radial overgrowth around the core without a well-developed granoblastic texture. The inner core consists of tiny mineral grains, usually submicroscopic in size, with brush-shaped aggregates of a

conspicuous radial appearance (PLATE I/4.). Among the core-forming phases in some samples spinel may be recognized under the microscope. Other breakdown minerals cannot be identified in the core, however, one of the microtextures studied also contains a kyanite grain in the centre. The textural relations are consistent with the interpretation that kyanite represents the original high pressure phase which became unstable during exhumation of the eclogite. The subsequent mineral zones formed due to a reaction between kyanite and other high pressure phases like pyroxene, garnet or zoisite.

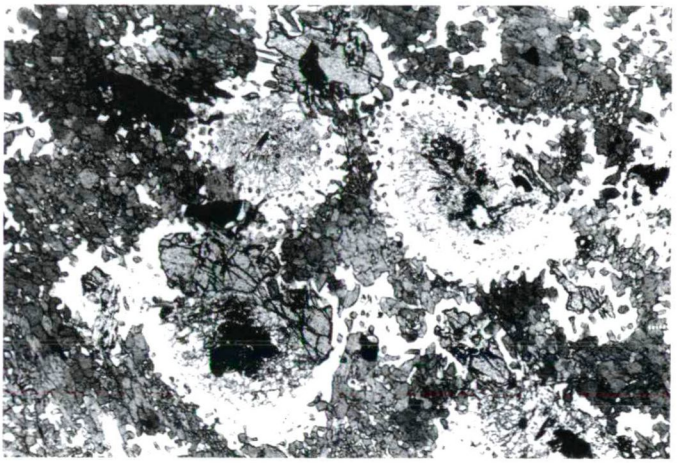


Plate I/2. Cluster of microtextures studied in a matrix composed mainly by amphibole (after pyroxene), plagioclase and garnet. N1, 50x. 1-amphibole; 2-plagioclase; 3-garnet

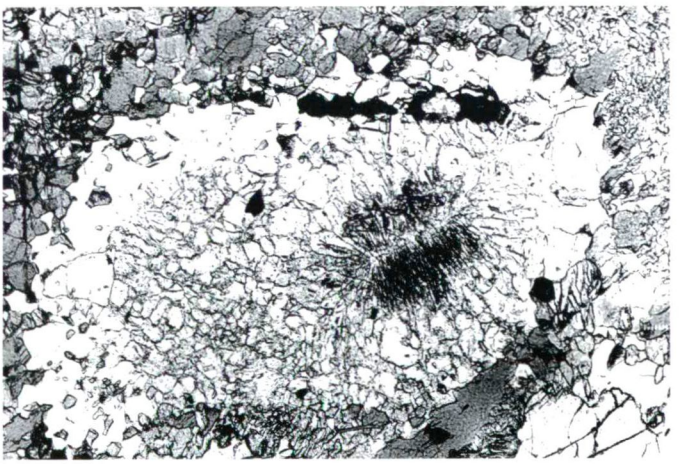


Plate I/3. The symplectitic internal core is rimmed by anorthite-rich plagioclase. The external rim is plagioclase of composition An_{45-50}. Note the significant difference in relief of the two feldspar phases. N1, 200x. 1-anorthite; 2-plagioclase

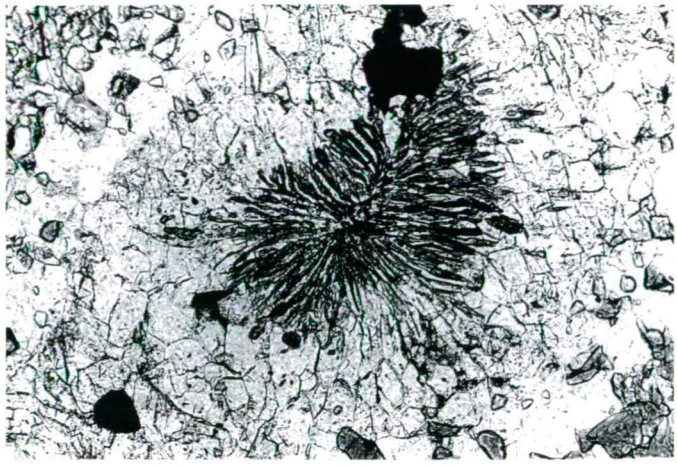


Plate I/4. Fine-grained symplectitic intergrowth of spinel and corundum forms radiating growth N1, 200x. 1-spinel (and corundum); 2-anorthite

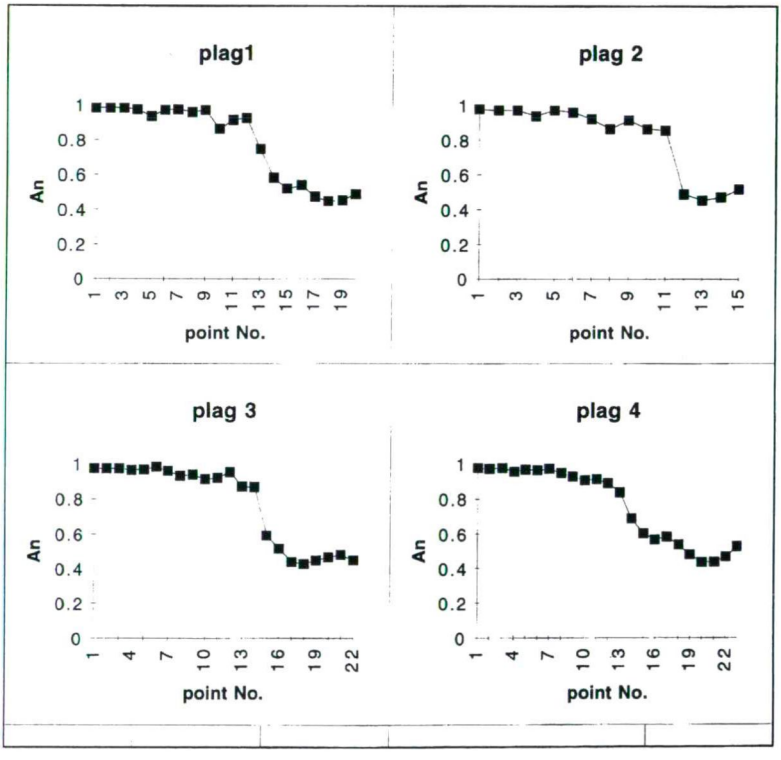


Fig. 1. Compositional change of plagioclase from core to rim in four different cases. Each step means 2 microns.

MINERAL CHEMISTRY

In order to be able to explain the formation of the microtexture, the exact composition of the subsequent minerals was measured by electron microprobe, and the submicroscopic mineral phases have been identified as well. For this purpose, element distribution (X-ray) maps were made by electron microprobe. The differences between the two outer plagioclase zones observed microscopically, may be explained by their chemical composition. The external shell consists of a feldspar of An_{50}, while the internal one of An_{95} plagioclase. The boundary is sharp, no continuous change was measured (fig. 1.). Based on the X-ray maps the spinel is principally hercynite, with significant amounts of Mg and Zn; other metals (Cr, Mn) were not detected (fig. 2/a-b.). However, the maps suggest a heterogenous composition of the spinel, the core being Mg-rich, while the rim contains more Fe. The qualitative results could be confirmed by quantitative point analyses on some relatively big spinel grains as well. In the average of four large grains, the spinel composition is the following: Hc: 79%, Sp: 13.5%, Gn: 7.5 %. The X-ray maps could supply also the last phase in the core: the exclusively Al-bearing mineral is corundum (fig. 3/a-b.).

In addition to the minerals mentioned the coronas also contain rutile inclusions, as well as late white mica flakes which appear sporadically without any relationship with the concentric breakdown structure. They are interpreted to be secondary to the corona formation.

DISCUSSION

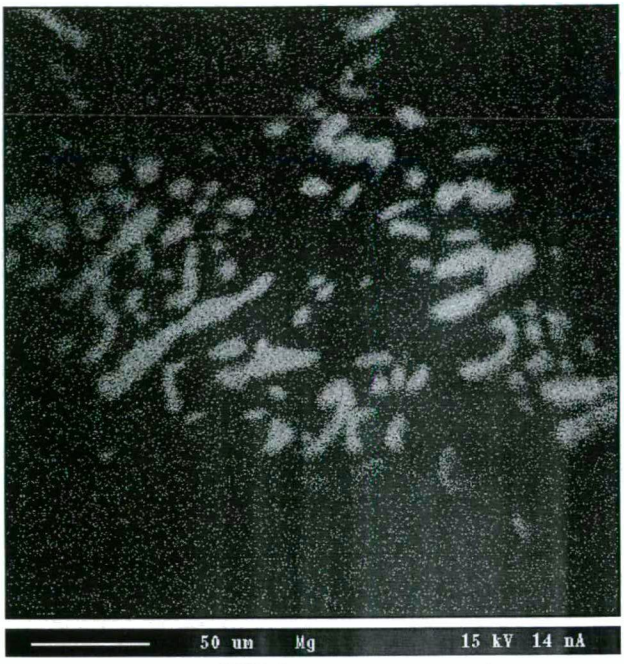
Possible breakdown reactions

The textural relationships detailed above suggest that the corona-forming mineral intergrowth formed due to reactions between kyanite and other HP-phases, principally pyroxene. In retrograded eclogite kyanite is usually replaced by mica; margarite has been observed also in the Alps by many authors (e.g. BORGHII, 1991; BIINO, 1995). Appearance of the corona structure around kyanite described above suggests uncommon circumstances during the retrograde development. Possible plagioclase, spinel and corundum-forming reactions between different end-members of pyroxene and kyanite are the following:

kyanite + jadeite = albite + corundum (1)
2 kyanite + hedenbergite = hercynite + anorthite + 2 quartz (2)
2 kyanite + diopside = spinel + anorthite + 2 quartz (3)
kyanite + Ca-Al-pyroxene = anorthite + corundum (4)

Although the original composition of the clinopyroxene was not preserved, HP-pyroxene is generally low in Ca. Further reactions likely to have taken place when producing the anorthite are therefore:

3 kyanite + grossular = 3 anorthite + corundum (5)
2 kyanite + almandine = 3 hercynite + 5 quartz (6)
2 kyanite + pyrop = 3 spinel + 5 quartz (7)
2 kyanite + 2 zoisite = 4 anorthite + corundum + H2O (8)



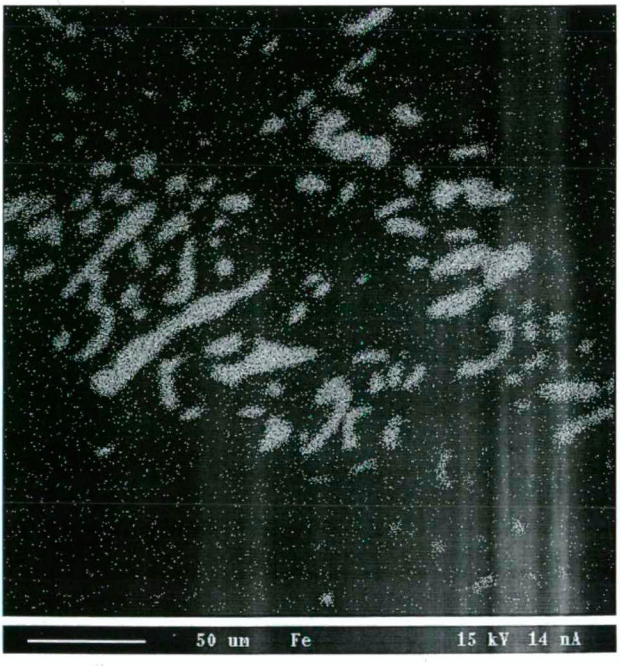


Fig. 2. X-ray maps of the spinel-bearing internal core. a) Mg; b) Fe

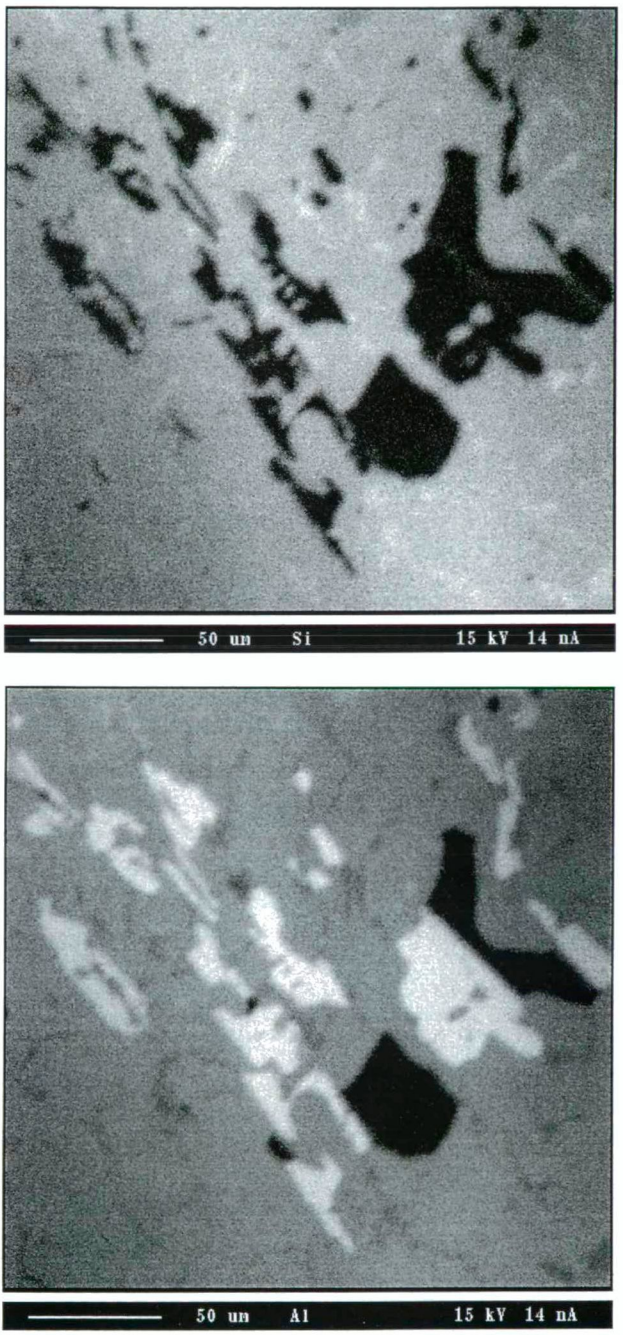


Fig. 3. X-ray maps of the corundum-bearing internal core a) Si; b) Al

Compound corona reaction rims may develop due either to sequential or simultaneous growth (GRANT, 1988). Subsequent reactions take place, for example, in forming garnet-bearing corona around olivin in metagabbros, where the primary spinel-clinopyroxene symplectite may be replaced by garnet later. In the given case there is no textural evidence of the replacement of earlier phases; all corona-forming minerals formed during the kyanite-pyroxene (garnet) reactions.

A complex corona structure may also form during the simultaneous reactions when the diffusion of certain elements is restricted. Resulting from the significant mobility differences, mineral zones with distinct composition may develop. In our case, kyanite serves Si and Al, while pyroxene and garnet Na, Ca, Fe and Mg to form the paragenesis stable under the new P, T conditions. Iron and magnesium appear in two phases. The starting pyroxene (garnet) and the core-forming spinel contain both elements, in about the same proportion. Similarly to calcium, they occur in the internal core suggesting free mobility. The behaviour of sodium, however, differs significantly from the first three cations. The only Na-bearing phase, the Ab-rich plagioclase, forms the external shell; the Ab-content of the internal feldspar zone is extremely low, less than 2 wt%. So, one clue to the development of the given corona structure should be the restricted mobility of Na.

In order to analyze the mobility of the kyanite-forming cations Si and Al, reactions (1)–(8) are instructive: on the right hand side the product minerals are those observed in the core (corundum, spinel) and in the rim (quartz, albite, anorthite) respectively. There is a conspicuous difference in the Si/Al ratio of these coupled mineral pairs. While the core contains no silicate phases (for both ideal spinel and corundum Si/Al=0) the outer shells are more and more rich in silica. Finally, the external zone is pure quartz. The increase of the Si/Al ratio towards the rim is presented along a hypothetic section of the microtexture (fig. 4.).

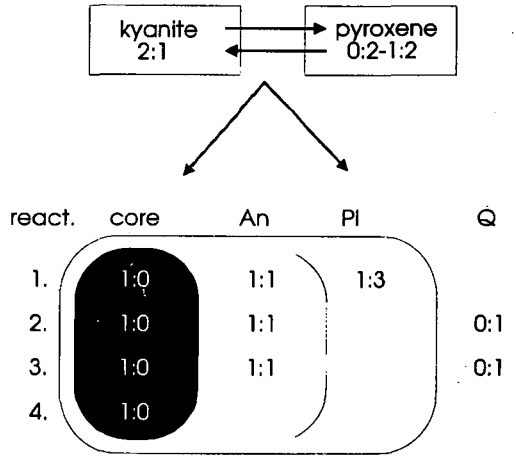


Fig. 4. Variation of the Al/Si ratio during the breakdown of the HP phases in the case of the reactions (1)–(4). Al-rich minerals are separated in the internal core.

The most significant difference among the subsequent zones of the microtexture studied appears in their Si/Al proportion. The main reason for the corona growth must have been the lower mobility of Al compared to Si during the breakdown of the high-P

paragenesis. This process could result in a diffusive gain of Al relative to Si in the core, and finally lead to the disequilibrium coexistence of quartz and corundum in the same system. Between these two phases the outer plagioclase rim formed an effective barrier controlling the diffusion of Al and Si.

When plotting the stability fields of the reactions listed above on a P-T map, decreasing pressure, but slightly increasing temperature during the breakdown may be seen (fig. 5.). The reactions define a wide pressure range, and reaction (4) gives significantly higher pressure than the others. This shows that anorthite (and corundum) must have developed prior to the other phases. This evidence is in good agreement with the different textural and geochemical features of the two plagioclase shells, suggesting that anorthite grew earlier and formed a radial corona overgrowth around the kyanite. The more sodic outer plagioclase rim, which presents a mutual granoblastic texture, likely grew under higher temperature conditions. So, not only the sodic-intermediate plagioclase shell played a role as an the effective barrier, but also the primary anorthite zone could separate Al-rich and Al-poor phases (corundum in the core).

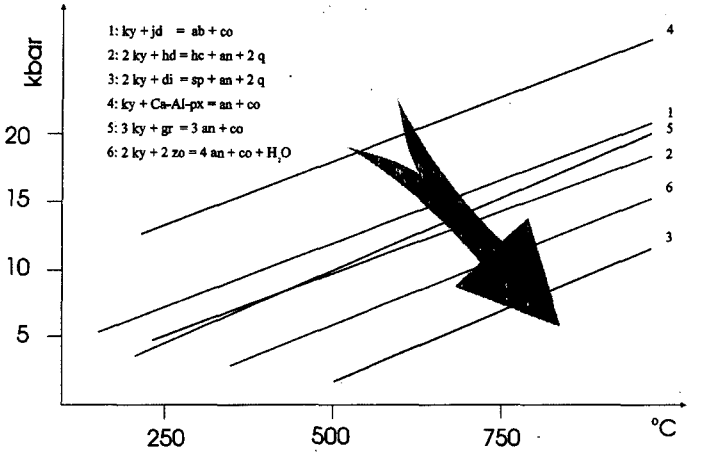


Fig. 5. Each reaction suggests increasing temperature during uplift. Thermodynamic calculations were performed with a TWQ software using the database of Berman (1988).

During a usual uplift both P and T decrease, the reheating refers to extreme geological conditions. Based on the current tectonic models for the Swiss Central Alps two solutions seem possible. Either the big granodiorite bodies found south-east of the eclogite locality intruded simultaneously with the uplift causing an extra heat-source, or the Adula nappe carried the heat when covering the underlying tectonic units (melon pit model, ENGI et al., 1995). When studying a breakdown microtexture of kyanite similar to the one described, HILL AND BALDWIN (1993) found a relationship with granodiorite bodies, which intruded due to the uplift of a metamorphic core complex in Papua New Guinea. To answer this question, however, we need more study.

Increasing temperature, of course, induced a more intensive sub-solidus diffusion, what lead to the corona growth around kyanite. At a certain value, however, also temperature had to drop and start decreasing. Because diffusion rate is an exponential function of temperature (PUTNIS, 1992), the diffusion and also the growth of the corona eventually

stopped allowing the metastable microtexture to persist. During cooling, probably due to the following reactions all Al-rich phases were replaced by mica:

$$\text{corundum} + K^+ + H_2O = \text{muscovite} \quad (9)$$
$$\text{kyanite} + K^+ + H_2O = \text{muscovite} \quad (10)$$
$$\text{hercynite} + K^+ + H_2O = \text{annite (in a biotite)} \quad (11)$$
$$\text{spinel} + K^+ + H_2O = \text{phlogopite (in a biotite)} \quad (12)$$

In several samples studied also isometric sets of plagioclase and mica, or plagioclase and corundum remind the previous existence of kyanite.

CONCLUSIONS

Compiled corona forming processes in the eclogite samples at Gorduno in the Swiss Central Alps represent a series of diffusion-controlled reactions. The corona structure is a result of reactions between kyanite and other HP phases; pyroxene, garnet and zoisite. In the internal core Al-rich minerals (corundum, spinel) are separated, and the Al/Si ratio decreases towards the rim (anorthite, plagioclase, quartz). The observed mineralogy formed due to the restricted mobility of Al relative to Si in high temperature conditions.

Due to cooling diffusion rate had to decrease making the persistence of the double corona structure possible.

ACKNOWLEDGEMENT

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REFERENCES

BERMAN, R. G. (1988): Internally-consistent thermodynamic data for stoichiometric minerals in the system Na_2O-K_2O-CaO-MgO-FeO-Fe_2O_3-Al_2O_3-SiO_2-TiO_2-H_2O-CO_2. J. Petrol. 29: 445–522

BIINO, G. (1995): Pre-Variscan evolution of the eclogitised mafic rocks from the Helvetic basement of the Central Alps. Eur. J. Mineral. 7: 57–70

BOCCHIO, R. (1975): Le eclogiti retrommetamorfiche di Gorduno. Periodico di Mineralogia – Roma. 44: 245–256

BORGHI, A. (1991): Margarite coronas after kyanite in the Seria dei Laghi (Southern Alps – northern Italy and Canton Ticino). Per. Mineral. 60: 45–54

ENGI, M.; TODD, C. S.; SCHMATZ, D. R. (1995): Tertiary metamorphic conditions in the eastern Lepontine Alps. Schweiz. Mineral. Petrol. Mitt. 75: 347–369

FORSTER, R. (1948): Geologisch-petrographische Untersuchungen im Gebiete noerdlich Locarno. Schweiz. Mineral. Petrol. Mitt. 13/2: 249–470

GRANT, S. M. (1988): Diffusion models for corona formation in metagabbros from the Western Grenville Province, Canada. Contrib. Mineral. Petrol. 98: 49–63

HILL, E. J.; BALDWIN, S. L. (1993): Exhumation of high-pressure metamorphic rocks during crustal extension in the D'Entrecasteaux region, Papua New Guinea. J. metamorphic Geol. 11: 261–277

PUTNIS, A. (1992): Introduction to mineral sciences. Cambridge University Press.

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